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LEVEL II

MISCELLANEOUS PAPER GL-79-4

EVALUATION OF THE EFFECTIVENESS OF MEMBRANES FOR PREVENTION OF CRACK REFLECTION IN THIN OVERLAYS

by

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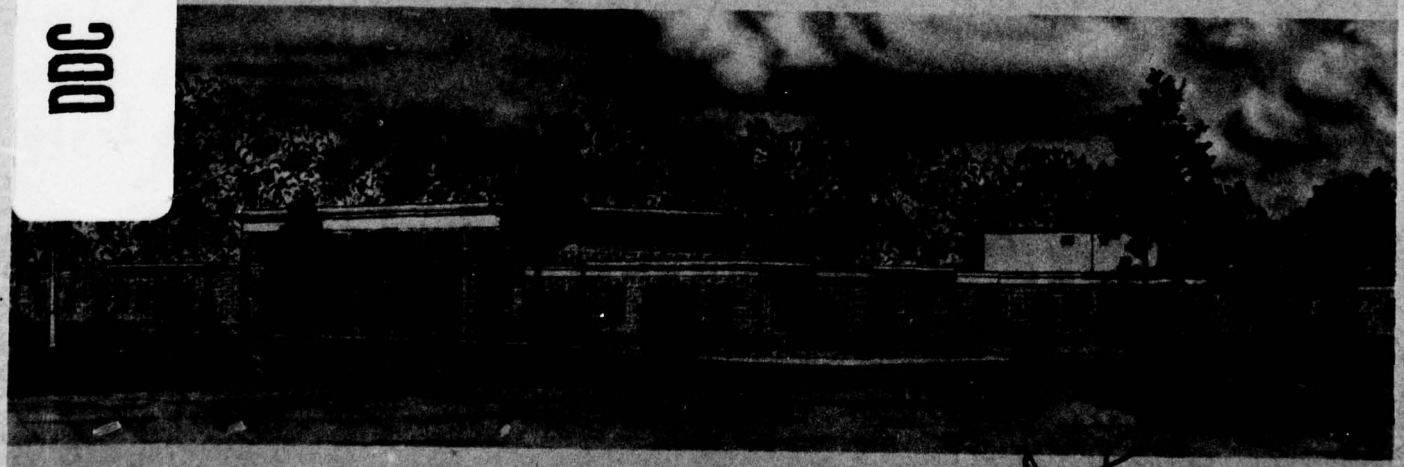
March 1979
Interim Report



Prepared for Headquarters, U. S. Army Forces Command
Fort McPherson, Ga. 30330

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Concrete overlays	Overlays (pavements)
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Membranes (airfields)	Pavements
Membranes (roads)	Reflection cracking

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is an interim report resulting from case studies of pavement performance conducted by the U. S. Army Engineer Waterways Experiment Station under contract order with the U. S. Army Forces Command. The purpose of this study was to determine if a stress-absorbing layer consisting of an asphalt-rubber membrane or a nonwoven fabric placed under a thin asphaltic concrete overlay (2 in. or less) will stop reflection cracking from occurring in the overlay. Field tests of two asphalt-rubber membrane formulations and three nonwoven

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20. ABSTRACT (Continued).

CONT

fabrics were placed on roads and airfield pavements at five Army installations in various areas of the United States. This report covers the construction of the test areas and performance after a 6-month period. A final report will be prepared on the performance of each material after a number of years of annual inspections.

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PREFACE

The U. S. Army Engineer Waterways Experiment Station (WES) was contracted by the Headquarters, U. S. Army Forces Command (FORSCOM), Fort McPherson, Georgia, to participate in an investigation of asphalt-rubber membranes and nonwoven fabrics as stress-absorbing layers for prevention of reflection cracking through thin overlays. Authority for the WES to participate in this program is contained in a letter dated 14 February 1977 from FORSCOM entitled "Testing of Asphalt-Rubber Membranes."

Test sites for use of the membrane materials were selected by FORSCOM at Fort Stewart, Georgia; Fort Devens, Massachusetts; Fort Lewis, Washington; and Fort Carson, Colorado. A nonwoven fabric material was being placed on a street at Fort Polk, Louisiana, and thus it was decided to add this location to the study.

The initial phase of this study was to provide technical assistance in preparation of contract specifications for the various membrane materials to be used and prepare an interim report covering the actual construction and performance of the materials for a period of approximately 6 months after construction. A final report will be prepared on the performance of each material after a period of several years, during which annual inspections of the test areas will be conducted.

The field investigations were conducted by Messrs. A. H. Joseph, S. L. Webster, P. J. Vedros, Jr., P. S. McCaffrey, Jr., and S. J. Alford, Geotechnical Laboratory (GL), WES. Manufacturer representatives involved during the placement of the materials were: Mr. E. S. Gothard, Monsanto Textiles Company, Messrs. W. S. Harmon and Danny Campbell, Celanese Fibers Marketing Company; Mr. Didrik A. Voss, Mirafi Systems, Wiley-Bailey, Incorporated; Messrs. Dick Armstrong, H. G. Lansdon, Bill Meggison, and Jim Slatten, Sahuaro Petroleum and Asphalt Company; Messrs. Jim Bagley, Bob Holbrook, and Ed Hamlin, Arizona Refining Company; Messrs. Bob Huff and R. J. Dzimian, U. S. Rubber Reclaiming Company; and Messrs. Dale Levy, Dane Spaulding, and Jim Dykes, Phillips Fibers Corporation.

Action officers for FORSCOM for the project were: Mr. F. W. B. Taylor, Headquarters; Major D. B. Murray, DFAE, Fort Devens; Mr. Lyman Smith, DFAE, Fort Lewis; Mr. T. D. Houston, DFAE, Fort Stewart; Mr. Tom Russell, DFAE, Fort Carson; and Mr. Herb Carter, DFAE, Fort Polk.

This report was prepared by Mr. P. J. Vedros, Jr., under the general supervision of Messrs. J. P. Sale and R. G. Ahlvin, Chief and Assistant Chief, GL, respectively; A. H. Joseph, Chief, Pavement Investigations Division; and R. L. Hutchinson, Pavement Program Manager.

COL J. L. Cannon, CE, was Director of the WES during the investigation and preparation of this report. Mr. F. R. Brown was Technical Director.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
gallons per square yard	4.5273	cubic decimetres per square metre
gallons (U. S. liquid)	3.785412	cubic decimetres
inches	25.4	millimetres
miles per hour (U. S. statute)	1.609344	kilometres per hour
ounces (mass)	28.34952	grams
ounces per square yard (mass)	33.90575	grams per square metre
pounds (force) per square inch	6894.757	pascals
pounds (mass)	0.4535924	kilograms
pounds (mass) per square yard	0.542492	kilograms per square metre
tons (mass)	907.1847	kilograms
yards	0.9144	metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

EVALUATION OF THE EFFECTIVENESS OF MEMBRANES FOR PREVENTION OF CRACK REFLECTION IN THIN OVERLAYS

PART I: INTRODUCTION

Background

1. Maintenance of pavements is one of the foremost problems facing pavement engineers today. A pavement is no sooner built than deterioration begins, and most pavements usually require several major corrective measures and possible complete reconstruction in a lifetime. The combined action of use and environment create these pavement problems. Cracking of the pavement surface as a result of repeated flexural, thermal, shrinkage, or tensile stresses seems to be inevitable. Overlaying cracked pavements is the customary method of maintenance. The subsequent reflection through overlays is a maintenance problem that has not been solved. Attempts have been made for years to find a means of stopping reflection cracking. Progress has been made where very thick overlays have been placed, but no solution has been found where overlays of 2 in.* or less are placed. An asphaltic concrete overlay thickness of 1-2 in. is the thickness normally placed on roads, streets, or airfields on many Army installations. Therefore, a solution to the reflective cracking problem of thin overlays at a reasonable cost would be a definite advancement in pavement maintenance.

Purpose and Scope

2. The purpose of this study was to determine if a stress-absorbing layer consisting of an asphalt-rubber membrane or a nonwoven fabric placed under a thin asphaltic concrete overlay (2 in. or less) will stop reflection cracking from occurring in the overlay.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 5.

3. The asphalt-rubber membranes selected for use in this study consisted of two formulations in which ground tire rubber is mixed with asphalt, sprayed on the existing pavement surface, and then covered with aggregate chips prior to placement of the overlay. One formulation developed by Sahuaro Petroleum and Asphalt Company consists of approximately 25 percent granulated crumb rubber (100 percent vulcanized) and 75 percent asphalt. About 5 to 7 percent kerosene is added to this mixture. The other formulation (G274) developed by U. S. Rubber Reclaiming Company consists of approximately 20 percent ground rubber (blend of 40 percent powdered devulcanized and 60 percent ground vulcanized) and 80 percent asphalt. About 2 percent extender oil is normally added to this mixture.

4. The fabrics selected for use in this study consisted of a 100 percent nonwoven polyester with the trade name Bidim (C-22), marketed by Monsanto Textiles Company, and a nonwoven polypropylene and nylon-sheathed polypropylene with the trade name Mirafi (140), marketed by Celanese Corporation. There are a number of other fabrics on the market that could have been considered for use in this study, but it was not possible to include others due to limited resources. It was desirable to use both a polyester and a polypropylene fabric, but the selection of the two fabrics used in this test series does not mean that they would perform any better than other fabrics that were available. It was learned after the test sections were constructed in the fall of 1977 that a polypropylene fabric with the trade name Petromat, which was marketed by Phillips Fibers Corporation, was placed on a street at Fort Polk, Louisiana. At the request of U. S. Army Forces Command (FORSCOM), this test section was added to the program for the U. S. Army Engineer Waterways Experiment Station (WES) to monitor the performance of this material. Because of some early distress that occurred in the Mirafi 140 fabric at two of the test installations, a small section of the Petromat fabric was also included in the test sections at Fort Carson, Colorado.

PART II: SITE SURVEYS

Fort Lewis, Washington

5. The areas selected for the test sections at Fort Lewis were located on Faith Avenue and Second Division Drive. Figure 1 shows a layout of the test locations. The initial survey of Second Division Drive indicated the cracking in the pavement surface to be very light, so it was recommended that only a surface seal coat of the two rubber formulations be placed. The performance of these two materials would be compared with the performance of a standard 1-in. overlay, which was considered to be the control section. As noted in Figure 1, the Sahuaro rubber material was placed in two locations on Second Division Drive. At one location, approximately 2330 ft long and the width of the roadway, the asphalt-rubber membrane was covered with chips that had been precoated with asphalt, and at the other location, approximately 1100 ft long, the membrane was covered with regular washed uncoated chips. The U. S. Rubber asphalt-rubber membrane, approximately 2450 ft long, was covered with precoated chips. The test sections on Faith Avenue were each 400 ft long and the width of the roadway. A 200-ft section of each fabric and the asphalt-rubber membrane was placed on each side of the median. A 1-1/2-in. overlay was placed over each material. The control section for this roadway was a standard 1-1/2-in.-thick overlay.

Fort Devens, Massachusetts

6. The areas selected for the test sections at Fort Devens were located on Moore Army Airfield (AAF) and Barnum Road. Figure 2 shows a layout of the test locations. As noted in Figure 2, the test sections at Moore AAF were located on three different areas of the airfield. Test areas of the fabric and asphalt-rubber membrane materials measuring 100 by 200 ft were placed on the NW-SE runway, 100 by 80 ft were placed on the N-S runway, and 100 by 100 ft were placed on the apron area. Each test area was overlaid with a 2-in.-thick asphaltic concrete overlay,

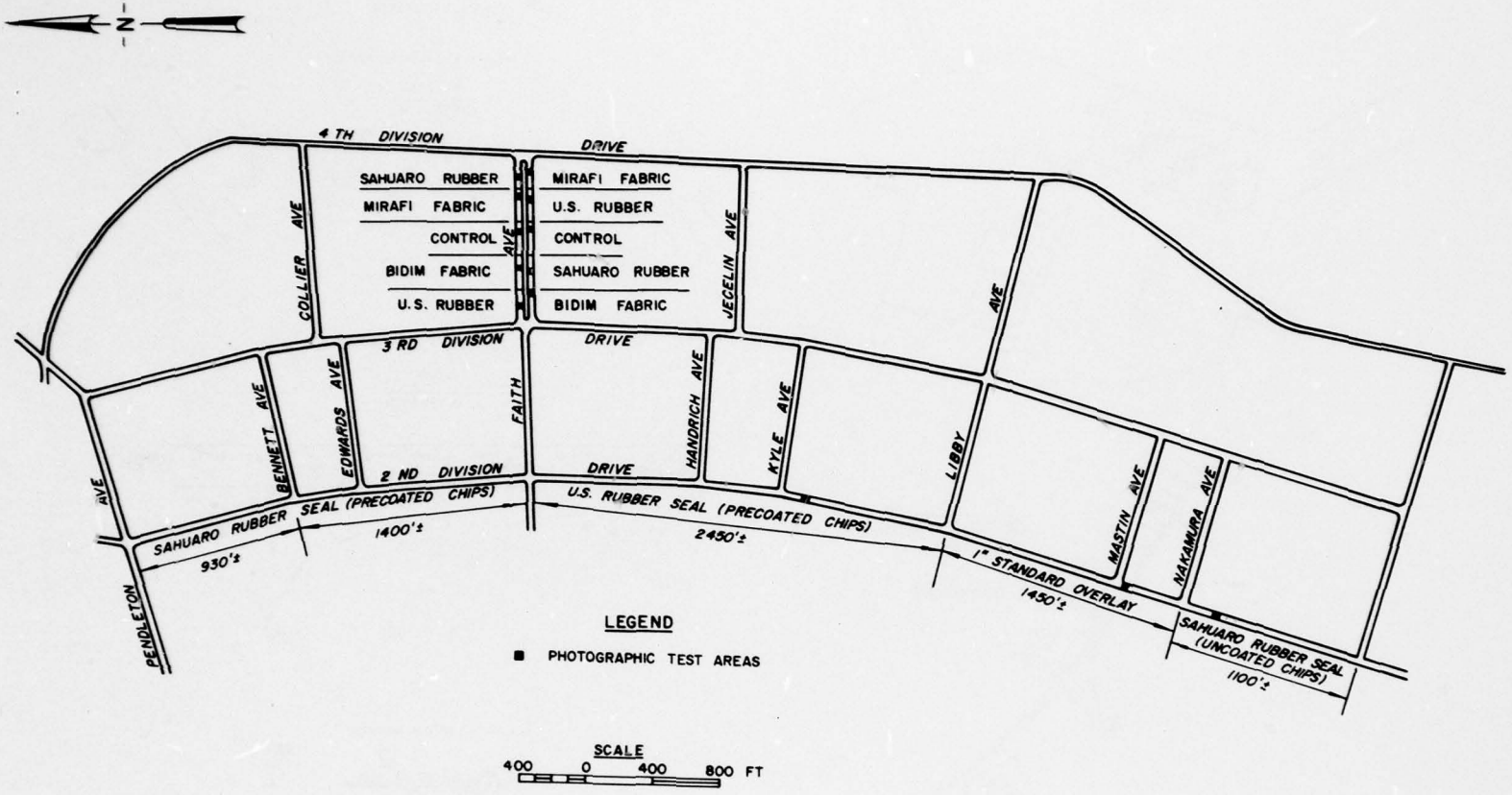


Figure 1. Location of test areas, Fort Lewis, Washington

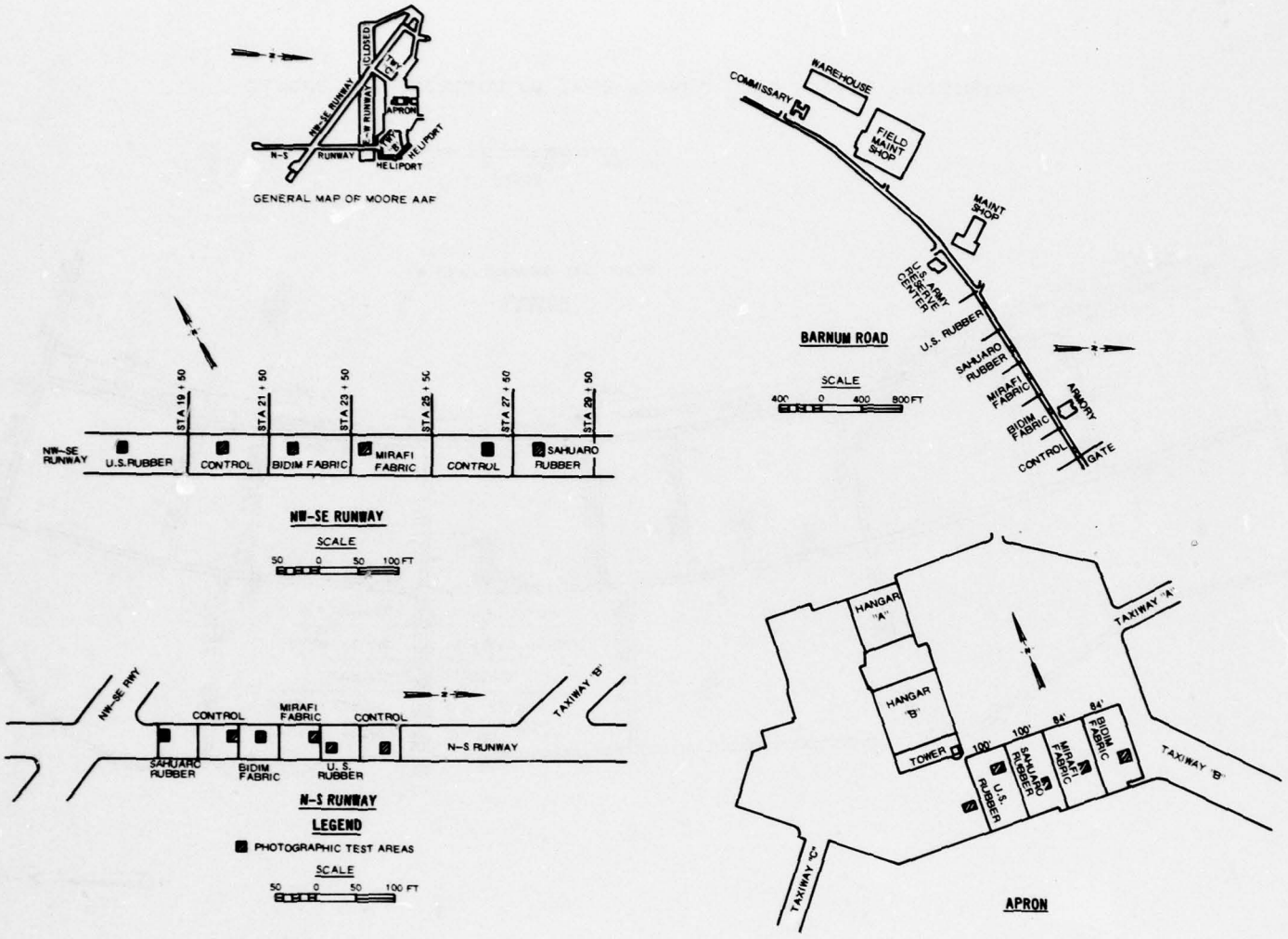


Figure 2. Location of test areas, Fort Devens, Massachusetts

and the control sections consisted of a standard 2-in.-thick asphaltic concrete overlay. The test areas on Barnum Road (Figure 2) consisted of fabric sections 325 ft long and 28 ft wide and the asphalt-rubber sections 400 ft long and 28 ft wide. These areas were also overlaid with 2 in. of asphaltic concrete.

Fort Stewart, Georgia

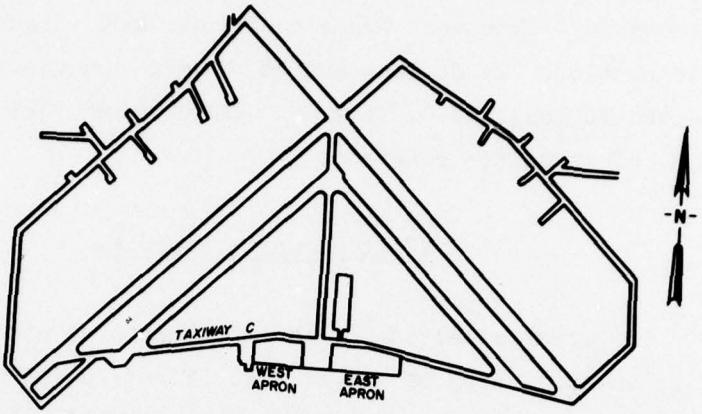
7. The areas selected for the test sections at Fort Stewart were located on an apron area of Wright AAF. Figure 3 shows a layout of the test areas. Each fabric and asphalt-rubber test section measured 100 by 250 ft and was overlaid with a 1-1/2-in. asphaltic concrete overlay. The control section was approximately 120 by 220 ft and consisted of a keystone course overlaid with a 1-1/2-in. asphaltic concrete. A keystone course has been used for a number of years as a means of minimizing reflective cracking and is now used as a standard with overlays.

Fort Polk, Louisiana

8. The entrance road to Fort Polk, Louisiana Avenue, was selected to receive a treatment of Petromat fabric during the overlay of the road. Figure 4 presents a layout showing the location of the area that was overlaid. From the entrance gate to Georgia Avenue, the Petromat fabric was placed on the roadway and the shoulders prior to placement of a 1-1/2-in. asphaltic concrete overlay. The next block from Georgia Avenue to Texas Avenue received only a 1-1/2-in. asphaltic concrete overlay with no fabric.

Fort Carson, Colorado

9. The areas selected for the test sections at Fort Carson were located on Wilderness Road. Figure 5 shows a layout of the test locations. As noted in Figure 5, the test sections of fabric and asphalt-rubber membrane are not located in one continuous test section but are



GENERAL LOCATION MAP

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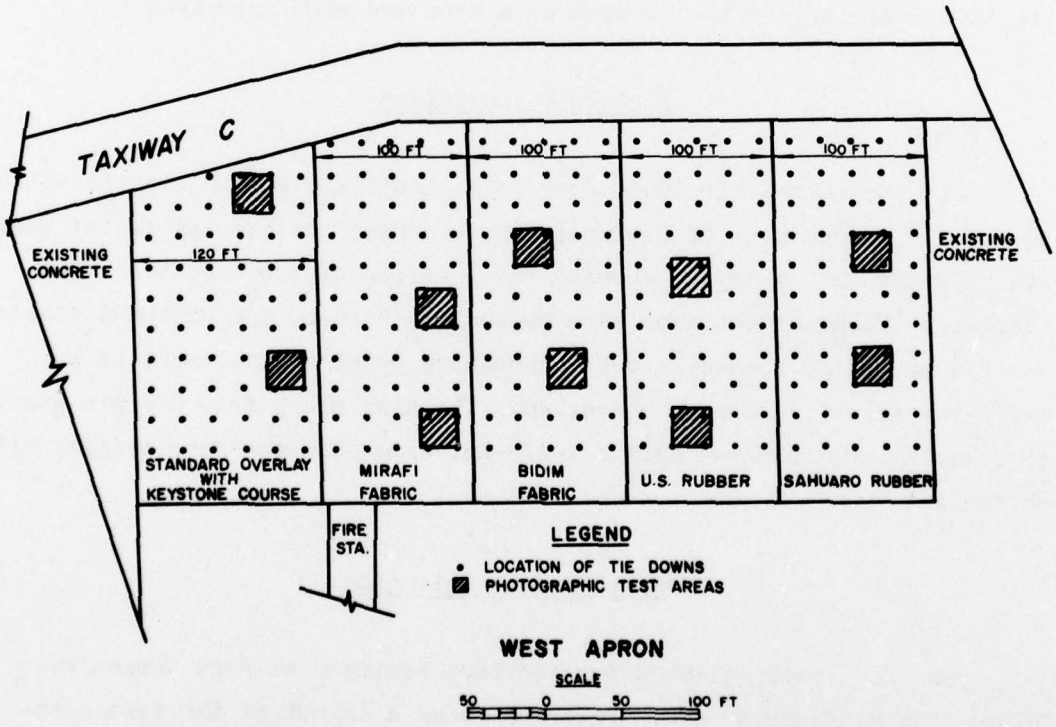
800 0 800 1600 FT



WEST APRON

SCALE
50 0 50 100 FT

Figure 3. Location of test areas, Fort Stewart, Georgia

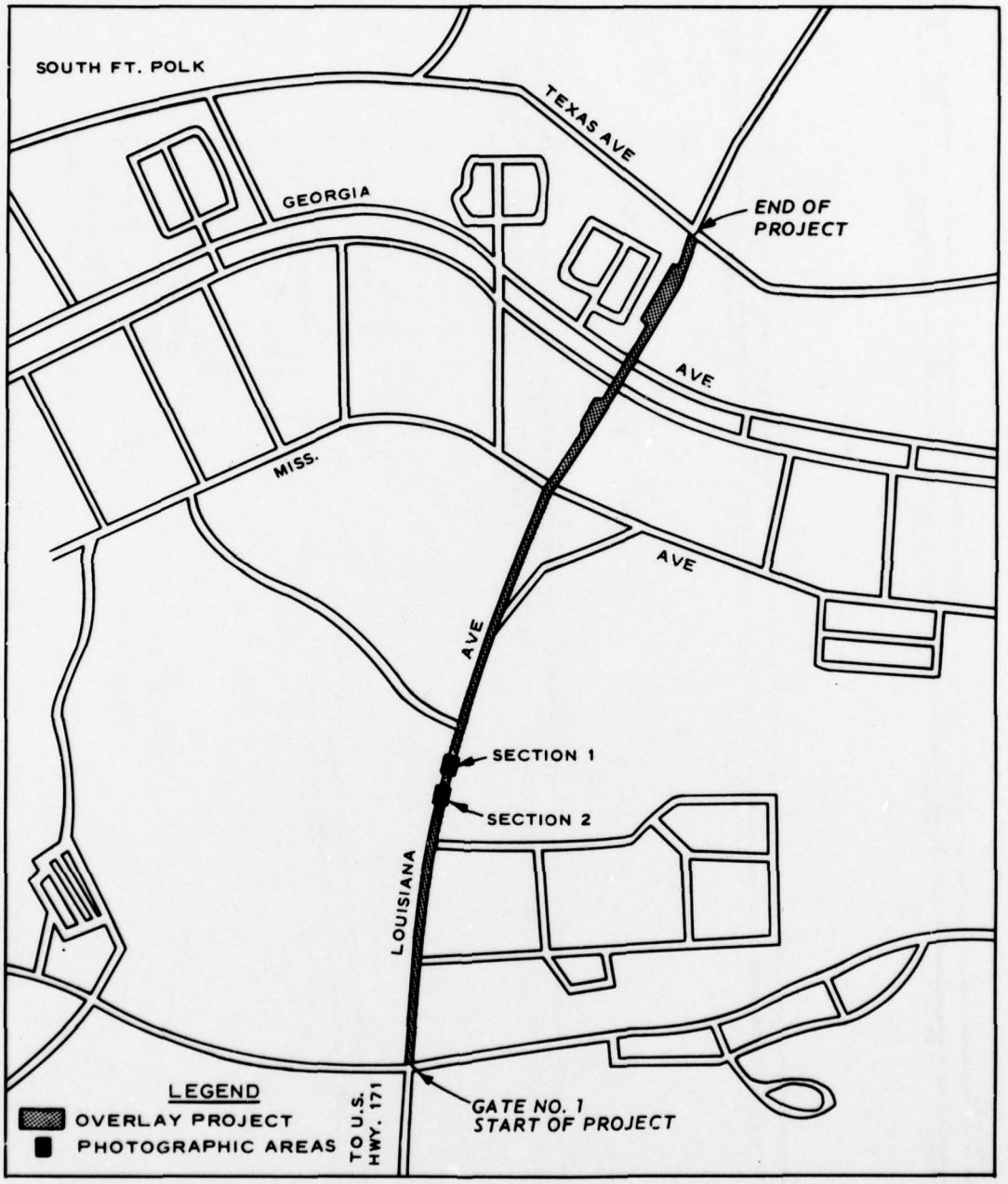


Figure 4. Location of test areas, Fort Polk, Louisiana

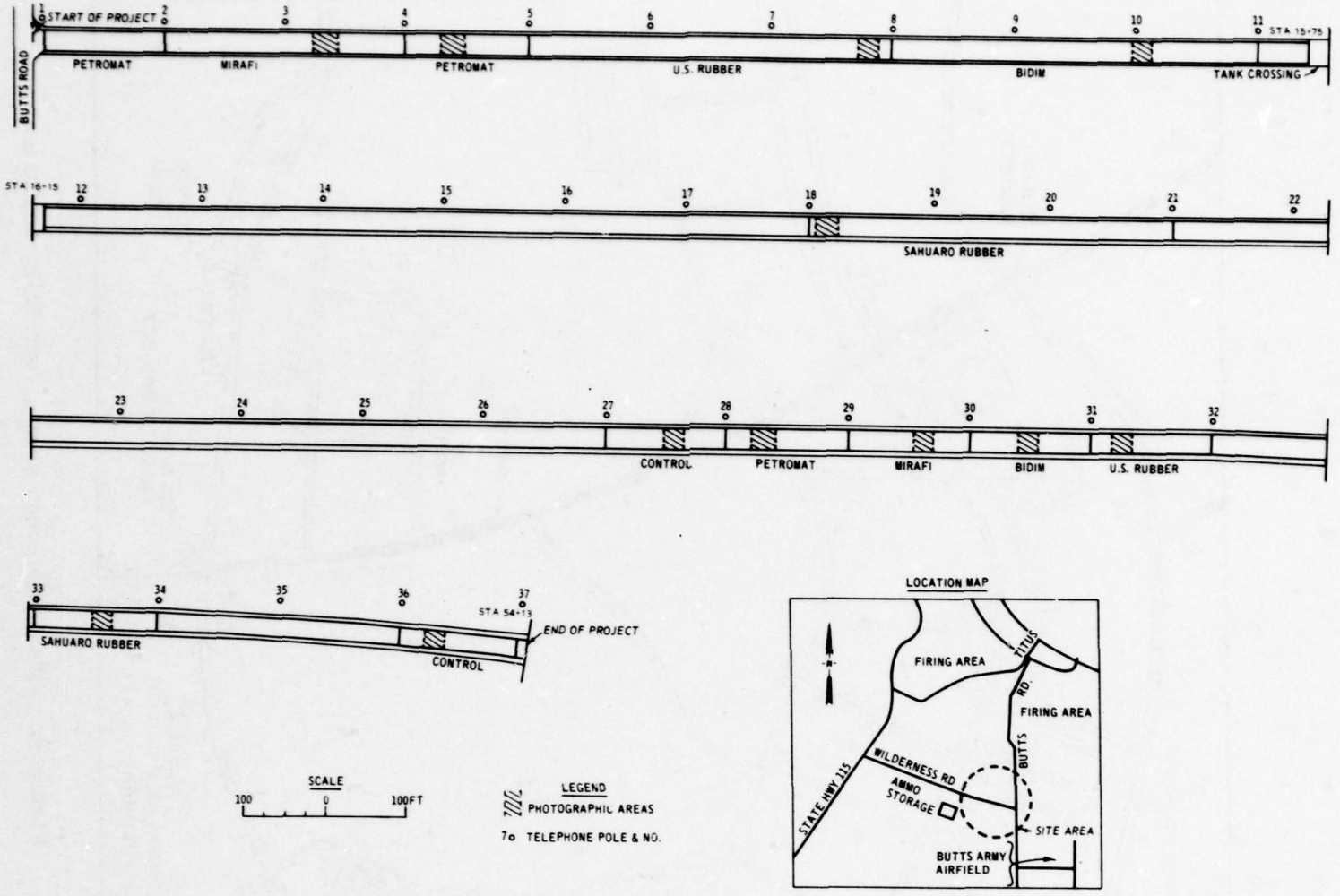


Figure 5. Location of test areas, Fort Carson, Colorado

intermittent along the roadway. The test sections were located in areas of the roadway that were considered to contain representative areas of cracking patterns.

PART III: CONSTRUCTION

10. The construction schedule for all test areas was planned to be completed during the construction season for 1977. However, it was not possible to complete construction at Fort Carson until the spring of 1978. Also, the weather conditions at Fort Devens and Fort Lewis were far from ideal for constructing the test sections due to the time of year. Rain and cold weather created some delays and may have some effect on the performance of the materials due to the conditions under which they were placed. However, all materials placed at an installation were under the same weather conditions; therefore, a comparison of the performance of one material relative to another should be an equitable analysis.

Fort Devens, Massachusetts

11. Prime contractor for the work at Fort Devens was P. J. Keating Company, Lunenburg, Massachusetts. Sealcoating, Incorporated, Hingham, Massachusetts, was the subcontractor for crack sealing and placement of the fabric test sections. Sahuaro Petroleum and Asphalt Company, Phoenix, Arizona, was the subcontractor for placement of the Sahuaro asphalt-rubber test sections. Arizona Refining Company, Phoenix, Arizona, was the subcontractor for placement of the U. S. Rubber asphalt-rubber test sections. New York District, Corps of Engineers, prepared the plans and specifications and provided the inspection for the work performed on Moore AAF. The Directorate of Facilities Engineering at Fort Devens prepared the plans and specifications for the work performed on Barnum Road.

12. A description of the two fabrics used in these tests was obtained from manufacturers' brochures* and data sheets as follows:

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* Description of fabrics obtained from advertisement brochures put out by Celanese, Monsanto, and Phillips.

a. Bidim. Bidim is a nonwoven continuous filament polyester fiber needled to provide mechanical interlocking. The fabric is decay resistant and withstands chemical attack from acid or alkaline soils but will degrade under prolonged exposure to ultraviolet light. The fabric is manufactured in the following weights and dimensions:

	C-22	C-28	C-34	C-38	C-42
Weight, oz/yd^2	4.5	5.9	9.6	12.4	19.4
(gm/m^2)	150	200	325	420	650

Widths are 4.2 m and 5.3 m (166 and 209 in.). Rolls come in 300-m (325-yd) lengths except C-42 which comes in 150-m (154-yd) lengths. The C-22 having a weight of 4.5 oz/yd^2 was used for all test sections.

b. Mirafi 140. Mirafi 140 is a nonwoven fabric constructed from two types of continuous filament fibers. One is a polypropylene homofilament and the other is a heterofilament composed of a polypropylene core covered with a nylon sheath. During the webmaking process, the heterofilaments are heat-bonded or fused at their crossover points, while the homofilament polypropylene, unaffected by heat, is mechanically interlocked. It is not significantly affected by alkalines and weak acids (PH 3). Sustained exposure to strong acids or sunlight may cause fabric property deterioration. Mirafi 140 has a thickness of 30 mils (0.03 in.) and weighs 140 gm/m^2 (4 oz/yd^2) and is manufactured in 4.5-m (14-ft, 9-in.) widths and 100-m (328-ft) lengths.

13. Background data for the pavement at Moore AAF and Barnum Road were obtained from evaluation reports and data obtained by the Fort Devens Facility Engineers. The original construction of the pavement at Moore AAF was accomplished in 1941 by the Works Progress Administration (WPA) and consisted of a 6-in. mixed in-place soil-cement base course with an asphaltic surface treatment. The runways, originally 150 ft wide, were widened to 300 ft by the Corps of Engineers in 1942 using the same construction. The runways were paved with 2 in. of asphaltic concrete in 1960. The parking apron was constructed in 1958-59 and consisted of a 6-in. soil-cement base and a surface treatment. A 1-1/2-in. asphaltic concrete surface was placed in 1960, and an overlay of 1-1/2 in. was placed in 1967. Evaluation tests in May 1977 indicated the pavements were structurally adequate to carry the aircraft loads

that were presently using the pavements. The cracking in the pavement surface appeared to be reflective cracking resulting from cracks in the soil-cement base material. All cracks on the NW-SE runway had been sealed in 1973, and there were some additional cracks that developed since that time which were not sealed under this contract. All cracks in the apron area were sealed except those in the area of the test sections where it was recommended that only half of these cracks be sealed. The background data for Barnum Road were not available. Cores taken from the roadway in November 1977 indicated the pavement structure to consist of from 1-1/2- to 2-in. asphaltic concrete surface over 5- to 7-in. asphalt-stabilized crushed rock base course. The crushed rock used in the base appeared to be about a 3-in. maximum size. The small amount of cracking in the pavement surface appeared to be the results of environmental effects rather than load associated. Present traffic is about 4000-5000 vehicles per day with the majority being automobiles. A more accurate traffic count will be provided in the final report of this study.

14. The two fabric test sections were placed on the NW-SE runway on the afternoon of 7 October 1977. The paint striping on the runway had been scraped off with a heater planer; in the test sections all loose material was swept from the pavement surface with a power broom. The Mirafi 140 fabric test section was placed first. A tack coat of AC-10 asphalt was applied by a distributor in a 15-ft width, the 200-ft length of the section. The AC-10 asphalt was supplied by Exxon of Everett, Massachusetts. Rate of application was 0.18-0.20 gal/sq yd. Air temperature was about 54°F, and temperature of asphalt at spraying was about 340°F. The roll of fabric used was 14 ft 9 in. wide, 328 ft long, and weighed 165 lb (Photo 1). Two men using hand-held tensioning devices had no problem unrolling the material on the freshly sprayed tack coat. Another two men were required to smooth the fabric as it was being laid (Photo 2). Any wrinkles that could not be straightened while unrolling were slit with a knife and made to lay flat. Technical specifications used for placement of the fabric materials are given in Appendix A. The Bidim C-22 fabric used was in a roll 17 ft 5 in. wide,

990 ft long, and weighed 535 lb. This size roll was too large and heavy to be handled by hand, so the roll was sawed in half with a chain saw (Photo 3). The fabric was very difficult to place wrinkle free, and the frayed edge caused by the sawing gave the fabric a very ragged appearance when placed (Photos 4 and 5). The AC-10 tack coat was sprayed at a rate of 0.22-0.25 gal/sq yd in a 10-ft width. All joints and overlaps on both fabric sections were sealed with joint seal material to glue the edges. After both fabric sections were placed, the area was rolled with a light pneumatic-tired roller (Photo 6).

15. On the morning of 8 October 1977, the fabric test sections located on the apron area were placed. The air temperature at the time of placement was 41°F. The AC-10 tack coat was sprayed at temperatures of about 365°F. The cracks in the northern half of the test sections on the apron area were sealed prior to being overlaid and those in the southern half were left unsealed. All cracks were blown free of grass and debris prior to sealing with joint seal material (Photo 7). The Mirafi 140 fabric was placed in the direction of the 200-ft length of the test section in the same manner as had been placed on the NW-SE runway. Due to the cool weather, the light pneumatic-tired roller was placed on the fabric immediately after the 200-ft length was placed (Photos 8 and 9). A different procedure from that used on the runway was tried for placement of the Bidim C-22 fabric. The material was left in a roll 17 ft 5 in. wide and unrolled in an area adjacent to the area that had received the tack coat. The material was laid in the short direction of the test area (84 ft), which was transverse to the Mirafi 140 fabric. Six or eight men would pick the fabric up and place it on the tack coat (Photo 10). This worked reasonably well as there was no wind blowing. The fabric edges were sealed with joint seal material (Photo 11). The unsealed cracks were very evident under the fabric (Photo 12). The completed fabric areas were well bonded to the pavement surface and looked to be in a fairly wrinkle-free condition (Photo 13).

16. The fabric test sections were placed on Barnum Road on 18 October 1977 and on the N-S runway on 26 October 1977. Because of traffic, all work had to be completed on the NW-SE runway before

placement of the fabric test sections on the N-S runway could be commenced. Placement procedures for the fabric on both Barnum Road and the N-S runway were the same as had been used on the apron.

17. The 2-in. asphaltic concrete overlays were placed over the fabrics on Barnum Road on 20 October 1977, on the NW-SE runway on 17-21 October 1977, on the apron area on 25-31 October 1977, and on the N-S runway on 1-8 November 1977. No problems, such as slippage of the overlay or pulling up of the fabric, were encountered during the paving operations.

18. Bids were received for the work at Moore AAF to place asphalt rubber not only on the test areas as indicated in Figure 2 but on the entire length of the NW-SE runway and the N-S runway. Arizona Refining Company was the successful bidder, and the U. S. Rubber asphalt-rubber mixture was placed on the runways and on the test sections. The Sahuaro asphalt-rubber mixture was only placed on the test sections. Arizona Refining started loading the blended rubber, which was stacked in 50-lb bags alongside the runway, into distributor trucks on the morning of 12 October 1978. The AC-10 asphalt was shipped from Exxon in Everett, Massachusetts, and transferred to the distributor trucks. Two percent extender oil, Califlux GP, was added to the asphalt in the distributor. The rubber was hand loaded on a screw conveyor that dumped it into the top of the truck (Photo 14). An air hose from a small air compressor, which was parked alongside the truck, was used to inject air into the mixture while the rubber was added. This was to aid in coating the rubber with asphalt. After mixing the rubber and asphalt, the temperature in the truck was raised to 400-425°F prior to spraying. Technical specifications used for placement of the asphalt-rubber mixtures are given in Appendix B. Prior to application of the asphalt rubber, the aggregate spreader, trucks, and rollers were lined up behind the distributor truck, to avoid a delay in placement of cover aggregate or rolling after placement of asphalt rubber (Photo 15). The asphalt-rubber mixture was applied at the rate of 0.7 gal/sq yd, and considerable smoke was evident when spraying the hot mixture (Photo 16). The hot, crushed aggregate was

spread at a rate of about 40 lb/sq yd and immediately rolled by self-propelled pneumatic rollers. The edge joint was swept by a rotary broom prior to the application of the next lane (Photo 17). Photo 18 shows a general view of one lane that had received the aggregate and had been rolled. Application of the asphalt-rubber and aggregate on the northwest end of the runway and the U. S. Rubber test section was completed on the morning of 13 October 1977. Application of the U. S. Rubber material on the apron test area was completed on the afternoon of 13 October 1977 (Photo 19). The loose cover aggregate that was not embedded in the asphalt-rubber mixture was swept and removed.

19. The Sahuaro asphalt-rubber mixture was placed in the test section on the NW-SE runway on the morning of 14 October 1977 and on the apron test section on the afternoon of 14 October 1977. The Sahuaro material is placed by distributor trucks equipped with special agitating equipment designed by Sahuaro Petroleum and Asphalt Company. Prior to the application of the asphalt-rubber mixture, a tack coat of RS-1 was applied at the rate of about 0.05 gal/sq yd. The rubber was hand loaded into the distributor truck and mixed; then, about 7 percent kerosene was added to the mixture to lower the viscosity of the material. The material was sprayed at the rate of 0.6 gal/sq yd and immediately covered with aggregate and rolled as had been done for application of the U. S. Rubber material. The application of asphalt-rubber on the N-S runway by Arizona Refining Company was done during the period of 27-31 October 1977. The asphalt rubber was applied on the test areas on Barnum Road on 18 October 1977 using the same procedures and rates as had been used at the airfield. The Sahuaro distributor truck was to be used for the scheduled test section work at Fort Stewart, Georgia, so the Sahuaro test section on the N-S runway was applied on 18 October 1977. A few light aircraft traveled over this area until the runway was closed on 25 October 1977. All control test sections (Figure 2) were overlaid with a standard 2-in. thickness of asphaltic concrete.

Fort Stewart, Georgia

20. The contractor for the work at Fort Stewart was Clay-Ric Construction Company, Brooklet, Georgia. The Directorate of Facilities Engineering at Fort Stewart prepared the plans and specifications for the work performed on the west apron at Wright AAF under project request V2-00146-7.

21. Background data for the pavements on Wright AAF were obtained from evaluation reports. The west apron was constructed in 1971 and consisted of 10-in. soil-cement base course with a 1-1/2-in. asphaltic concrete surface. Reflective cracking had occurred in the asphaltic surface as a result of cracks in the soil-cement base (Photo 20). The cracks had not been sealed and were about 1/4-1/2 in. wide. The pavements appeared to be structurally adequate to carry the aircraft loads.

22. On 18 October 1977, the control section (Figure 3) was placed, which consisted of a conventional surface treatment (keystone course) of crushed granite having gradations of 95-100 percent of aggregate passing a 1-in. sieve, 25-60 percent passing the 1/2-in. sieve, and 0-5 percent passing the No. 8 sieve. The weather was clear and the temperature was approximately 65°F. The test section area was swept, and AC-10 asphalt sprayed at a temperature of 350°F and at a rate of 0.35 gal/sq yd. The keystone aggregate was then placed immediately by a self-propelled aggregate spreader at a rate of 70 lb/sq yd. The crushed stone was rolled using an 8- to 10-ton rubber-tired roller followed by a 5- to 8-ton steel-wheel roller.

23. The Mirafi 140 and the Bidim C-22 fabrics were installed on the morning of 19-20 October 1977. Air temperature during installation of the fabrics ranged between 65 and 75°F. No cracks were filled prior to placement of the fabric. A CRS-2 emulsion was selected for use as a tack coat for the fabrics. The emulsion was sprayed at a rate of about 0.27 gal/sq yd (residual asphalt of 0.18 gal/sq yd) for the Mirafi 140 test sections and 0.32 gal/sq yd (residual asphalt of 0.21 gal/sq yd) for the Bidim C-22 test sections. The spraying temperature of the CRS-2 emulsion ranged from 140 to 150°F. The fabrics were not placed until

the emulsified asphalt had cured sufficiently for the total surface to change from a brown to a glossy black color. This generally required between 15 to 30 min. To speed the placement of the fabrics, the emulsion was sprayed in the 100-ft width of more than one test area at a time for both the Mirafi 140 and the Bidim C-22. This allowed the emulsion to cure in one area while the fabric was being placed in the other. The first few feet of each spray lane received a slightly heavier coat of asphalt because the distributor did not get a running start before spraying. Longitudinal overlap joints of 4-9 in. were used for both fabrics (Photo 21). When the asphalt was sprayed on the Mirafi 140 fabric in forming the joints, the fabric would form very noticeable wrinkles (Photo 22). This did not occur with the Bidim C-22 fabric. In the transverse direction, the Bidim C-22 fabric overlapped the Mirafi 140 about 1 ft since the direction of paving would be across the Bidim C-22 to the Mirafi 140.

24. The Mirafi 140 was packaged in a roll 328 ft long and 14 ft 9 in. wide, and the Bidim C-22 was packaged in a roll 100 ft long and 13 ft 8 in. wide. Fabric laydown was accomplished by attaching a 1-in.-diam support pipe and hand-held brake devices to the fabric roll and adjusting each brake to provide uniform drag. The fabric was then placed by unrolling approximately 20 ft of fabric, stretching the fabric taut and wrinkle free, and lowering it into the asphalt (Photo 23). A few wrinkles did develop in the Mirafi 140 fabric, but these were cut and the excess material overlapped to form a flat surface. Nine lanes of Bidim C-22 and 11 lanes of Mirafi 140 were placed on 19 October 1977. It was decided not to roll the fabric with a rubber-tired roller until the next day in order to allow the asphalt to cure overnight. The remainder of the fabric was placed on 20 October 1977, and an 8- to 10-ton rubber-tired roller was used to roll the entire fabric surface. The only change in fabric placement technique was in the last lane of each fabric that was placed. In this lane the fabrics were placed within approximately 5 min after the emulsion was sprayed. Both fabrics blotted up the uncured emulsion with the Mirafi 140 fabric surface being much blacker (Photo 24). Both fabric lanes were rolled within approximately 30 min

after placement with no problems encountered. The joint between the two fabrics had to be sanded lightly because the roller tires were picking up excess asphalt in this area.

25. Arizona Refining Company mixed the U. S. Rubber material and the asphalt during the night of 20 October 1977 for placement of the test section the morning of 21 October 1977. The AC-10 asphalt was obtained from American Oil Company. Approximately 2 percent extender oil was added to the asphalt prior to the addition of the rubber. The test section area was sprayed in the short direction (100-ft width) of the section due to work being done on the taxiway north of the section and no area for equipment to maneuver on the south end (Photo 25). The asphalt-rubber mixture was applied at a rate of 0.7 gal/sq yd, and the aggregate chips were placed at a rate of about 40 lb/sq yd and immediately rolled by self-propelled pneumatic rollers. The Sahuaro material was mixed on the morning of 21 October 1977 and applied the afternoon of 21 October. The ground rubber was hand dumped at the top of the distributor truck (Photo 26). The kerosene (about 5 percent) was introduced into the asphalt-rubber mixture from 55-gal drums through a pump at the bottom of the distributor (Photo 27). Prior to the application of the asphalt-rubber mixture, a light tack coat of AC-10 was applied on the test area at a rate of about 0.05 gal/sq yd (Photo 28). The asphalt-rubber mixture was applied at a rate of 0.6 gal/sq yd, and the aggregate chips were placed at a rate of about 40 lb/sq yd and immediately rolled with self-propelled pneumatic rollers (Photo 29). Both asphalt-rubber membrane test areas were swept to remove all loose aggregate not embedded in the asphalt rubber.

26. All test sections were overlaid with a 1-1/2-in.-thick surface course of bituminous concrete. Overlay was placed on Friday, 28 October, and Monday, 31 October 1978. The design mix, prepared in accordance with contract specifications, had the following gradation:

Sieve Size, in.	Job-Mix Formula	Limits
3/4	100	100
1/2	98	94-100
3/8	86	82-90
No. 4	65	61-69
No. 8	52	49-55
No. 16	40	37-43
No. 30	30	27-33
No. 50	20	17-23
No. 100	12	10-14
No. 200	8	6-10

Chevron Asphalt, AC-20, from Savannah, Georgia, with 1 percent Kling antistripping agent was used in the mix. An asphalt content of 5.8 percent was used. The asphalt mix was placed at a temperature of about 285-290°F. In the first spreader lane of bituminous concrete placed on the south edge of the apron, it was noted that the mix began to bleed at the juncture of the control section and the Mirafi 140 fabric section. This was caused by the excess emulsion tack material at this point. As a corrective measure, the contractor was instructed to apply a thin layer of asphaltic mix over the juncture of the control and Mirafi 140 fabric sections, the Mirafi 140 and Bidim C-22 fabric sections, and the Bidim C-22 and U. S. Rubber asphalt-rubber membrane sections prior to placement of the overlay. No further problem with bleeding was experienced during the laydown operations. A tar-emulsion seal coat was placed on the apron area in December 1977 to protect the pavement surface from aircraft fuel spillage that may occur.

Fort Lewis, Washington

27. The contractor for the work at Fort Lewis was Woodworth and Company, Incorporated, 1200 East D. St., Tacoma, Washington. The Directorate of Facilities Engineering at Fort Lewis prepared the plans and specifications for the work performed on Faith Avenue under project request 25593-76 and on Second Division Drive under project request 26471-76.

28. Background data for the pavements were obtained from the Facilities Engineer. Second Division Drive was constructed in 1950 of a crushed rock base course with a surface of about 1-1/2-in. plant-mix asphalt. The date of construction of Faith Avenue is not known. However, the pavement section was determined to consist of a crushed rock base course with a 1-1/2-in. plant-mix asphaltic concrete surface. Pavement cracking on Second Division Drive was very light (Photo 30), and on Faith Avenue the cracking tended to be localized (Photo 31). As mentioned previously, a surface seal of asphalt rubber and chips was placed on Second Division Drive along with a standard 1-in. asphaltic concrete overlay as a control section. The test sections of fabric and asphalt-rubber membrane as an interlayer between a 1-1/2-in. asphaltic concrete overlay were placed on Faith Avenue.

29. Sahuaro brought the AR-1000 asphalt in the asphalt-rubber mixture that was placed on Second Division Drive from Spokane, Washington, in their distributor truck. Work was started on the 1100-ft section on the south end of Second Division Drive. A light tack of about 0.05 gal/sq yd of CSS1 emulsion (0.03-gal/sq-yd residual asphalt) was applied, but there was some delay in application of the asphalt-rubber membrane due to the tack not breaking because of the cool weather. The contractor also did not apply the tack as early in the morning as had been scheduled, and the asphalt-rubber material had to be kept heating for a number of hours. Representatives for the Sahuaro material recommend that the material should be sprayed within 2 hr after mixing of rubber and kerosene. The asphalt-rubber material was applied at a rate of 0.65 gal/sq yd; then heated, uncoated, 5/8-in. maximum-size aggregate chips were applied at a cover rate of approximately 30 lb/sq yd (Photo 32). The area was rolled with pneumatic-tired rollers immediately after application of the chips. The north 2330-ft section was placed next by Sahuaro; then heated, precoated chips (chips precoated with about 0.75 percent asphalt) were applied in this area. The tack material had been sprayed long enough before the application so that there was no delay in waiting for the tack to cure. After completion of the areas on Second Division Drive, Sahuaro applied their material on the two test

areas on Faith Avenue. All cracks had been sealed with AR-4000 asphalt on Faith Avenue on 4 October 1977 (Photo 33). The asphalt rubber was applied on Faith Avenue at a rate of about 0.6 gal/sq yd (Photo 34); then heated, uncoated chips were placed immediately after spray application at a rate of about 30 lb/sq yd (Photo 35). The joints were swept with a power broom prior to application of the next distributor lane (Photo 36). The air temperature during application of the Sahuaro material varied from the middle 40°F temperature in the morning to the high 50's in the afternoon with an overnight low of about 34°F.

30. Arizona Refining Company was scheduled to apply the U. S. Rubber asphalt mixture on 6 October 1977. The weather was cloudy and damp with a temperature of about 50°F. The overnight low was about 37°F. Rubber was mixed with locally procured AR-4000 asphalt. The asphalt-rubber material was sprayed on the test sections on Faith Avenue at a rate of 0.7 gal/sq yd, and precoated chips were used for the cover aggregate. Chips were spread at a rate of about 30 lb/sq yd. Two 12-ft-wide and one 4-ft-wide spray applications were made by the distributor to cover the roadway. Self-propelled pneumatic-tired rollers followed the chip spreader. For traffic convenience, the area on Second Division Drive was divided into two sections for application of the asphalt rubber. The portion of the street between Libby Avenue and Hendrick Avenue was sprayed and chipped with precoated aggregate. It started raining and the second portion had to be delayed until the next day. On 7 October 1977, the road was still damp from the day before, and a torch was used to try to dry the surface as much as possible. The asphalt-rubber mixture that had cooled down in the distributor from the previous day was reheated and used. One small strip had not been dried properly and peeled up (Photo 37). The asphalt-rubber membrane in this area was cut out, and the pavement surface dried properly. Asphalt-rubber membrane and chips were reapplied. Air temperature at the time of application of the asphalt-rubber membrane was about 53°F.

31. An attempt was made on 6 October 1977 to place one of the fabric sections on Faith Avenue after the work on Second Division Drive was finished. The 200-ft section was sprayed with CSS1 emulsion at the

rate of 0.15 gal/sq yd. Rain occurred before the tack had broken; washing it off and placing the four fabric sections had to be delayed until 10 October 1977. The contractor agreed to use AR-1000 asphalt for a tack material rather than the CSS1 emulsion. The test sections were all swept on 10 October 1977 in preparation for the placement of the fabric. The Bidim C-22 section was sprayed with an asphalt tack at the rate of 0.20 gal/sq yd. The fabric could not be handled in the large roll, so a piece 105 ft long was unrolled in an area adjacent to the test section, and eight men hand carried the fabric and placed it in the tack material (Photo 38). This application procedure worked well. Proper joints were made and the fabric was placed fairly wrinkle free. The Mirafi 140 fabric was placed by unrolling the fabric from the roll into the tack material that had been sprayed at a rate of about 0.15 gal/sq yd (Photo 39). There were considerable wrinkles in the fabric on the roll, and it was difficult to place the fabric wrinkle free. It was necessary a couple of times to slit the wrinkle to realign the unrolling of the fabric. Generally, all fabrics appeared to be in very good condition after installation.

32. The 1-in.-thick asphaltic concrete hot mix placed on Second Division Drive on 12 October 1977 was a standard Class G state mix and was applied at a temperature of about 300°F. After completion of paving on Second Division Drive, the paver was moved to Faith Avenue, and a 1-1/2-in. thickness of pavement was placed over all test sections. Paving over the fabrics presented no problems. All paving was completed on 12 October 1977.

Fort Polk, Louisiana

33. The contractor for the work at Fort Polk was L. H. Bossier Construction Company, Alexandria, Louisiana. The Directorate of Facilities Engineering at Fort Polk prepared the plans and specifications for the work performed on Louisiana Avenue under project No. SB00018. As stated previously, WES was not involved in the initial planning of this work as they were for the other installations and did not have a representative

at the installation at the time of the placement of the fabric material. Photographs taken before and during construction were provided by the Facilities Engineer.

34. Louisiana Avenue, which is the entrance road for Fort Polk through Gate No. 1, was constructed of 6-in. jointed portland cement concrete (JC). The date of original construction is not known. The JC pavement was overlaid in 1962 with 2 in. of asphaltic concrete. The joints in the JC pavement have reflected through the asphaltic overlay (Photo 40). There is some cracking in the asphaltic concrete shoulder pavements. The work under this contract consisted of cleaning and sealing the cracks caused by the underlying JC pavement joints and placement of Petromat fabric over the 24-ft roadway and the shoulders. The fabric was placed on the pavement from the entrance gate to Georgia Avenue (Figure 4), and this area received a 1-1/2-in.-thick asphaltic concrete overlay. From Georgia Avenue to Texas Avenue, a 2-in.-thick asphaltic concrete overlay was placed without fabric. The shoulders were overlaid with a 1-in.-thick, open-textured asphaltic concrete from the entrance gate to Georgia Avenue and a 1/2-in. thickness of open-textured asphaltic concrete from Georgia Avenue to Texas Avenue. The fabric and overlay were placed on the main roadway in December 1977, and the shoulder pavements and fabric were placed in January 1978.

35. The fabric used for these tests, Petromat-Paving Grade, is a nonwoven polypropylene fabric manufactured by Phillips Fibers Corporation. The material weighs 4.2 oz/sq yd and is manufactured in rolls 300 ft long and 75 and 150 in. wide. The 150-in.-wide fabric was used at Fort Polk.

36. The weather was quite cool and wet during the period of work on Louisiana Avenue. The asphalt tack material used for placement of the Petromat fabric was AC-20 paving grade asphalt. Approximately 0.25-gal/sq-yd tack was to be placed prior to placement of fabric, but as shown in Photo 41, the asphalt distributor did not spray a uniform tack coat as specified. The fabric was placed with a small tractor, equipped with special attachments to lay fabric (Photo 42). The tractor operator was inexperienced in this work and did not lay a wrinkle-free

fabric (Photo 43). No problems were reported in the placement of the overlay over the fabric.

Fort Carson, Colorado

37. The contractor for the work at Fort Carson was Schmidt-Tiago Construction Company, 2635 Delta Drive, Colorado Springs, Colorado. The Directorate of Facilities Engineering at Fort Carson prepared the plans and specifications for the work performed on Wilderness Road under project request No. 71-77. The work consisted of widening the existing 20-ft roadway to a 24-ft width (approximately 2 ft on each side) and a 4-ft gravel shoulder on each side of the roadway. Widening construction consisted of a 9-in. subbase material, a 6-in. stabilized aggregate base, and a 3-in. asphaltic surface.

38. Background data for this roadway was not available. Three borings made in the roadway by the Facilities Engineer indicated the structure of the existing roadway to consist of a pit-run gravel base material ranging from about 8 to 11 in. with a 1-1/2-in. asphaltic surface. Trucks hauling explosives from the ammo storage area located adjacent to Wilderness Road broke the pavement surface along the pavement edges, narrowed the road to about 20 ft, and thus necessitated the widening work done under this contract. Except for the edge condition, the roadway appeared to be carrying the loads satisfactorily. The pavement widening and gravel shoulder work was completed during the week of 3 July 1978.

39. A preconstruction meeting was held on 10 July 1978 to discuss the placement of the fabric and asphalt-rubber test areas in order to avoid minor problems that were encountered at the other installations. A building paper was specified to be used at the start and ending of each test section so that a buildup of tack material would not occur. It was recommended that the fabric test areas be placed first so that the gravel cover aggregate from the asphalt-rubber sections would not lodge under the fabric as had happened at Fort Lewis. It was required that the fabric width be cut to the width of the 24-ft roadway either

before or after placement. An AC-10 asphalt tack material was specified for use on the fabric test areas, while an SS-1 emulsion was specified for use as a tack material for the Sahuaro asphalt-rubber test areas.

40. All fabric test areas indicated in Figure 5 were placed during the day on 12 July 1978. As the paving operations would proceed from the east end of the road (adjacent to Butts Road) to the west, the first fabric test area placed was the Bidim C-22 fabric located between telephone poles Nos. 30 and 31 (Figure 5). This was done so that the laps on one fabric to the other would be in the right direction and would not be affected by the paving machine. The weather was sunny, and the air temperature varied from about 80°F in the morning when first test areas were placed to a high of 95°F in the afternoon.

41. Arizona Refining Company used their distributor truck to spray the AC-10 tack material for the fabric test sections. The AC-10 was obtained from Continental Oil Company in Denver. Initial spray of tack for the first lane of the Bidim C-22 fabric resulted in only about 0.15 gal/sq yd of material placed when about 0.22 gal/sq yd was required (Photo 44). This was because the AC-10 was not hot enough to spray properly. The material was heated to about 310°F and reapplied. Total amount of tack material for the first lane of Bidim C-22 was about 0.30 gal/sq yd. The rate of application was controlled much better after the material was heated to the higher temperature. The Bidim C-22 fabric was received in rolls 200 ft long and 13 ft 10 in. wide and was placed by two men holding a 1-in. pipe suspended through the core of the roll and unrolling the fabric in the fresh tack material (Photo 45). A longitudinal lap joint of about 6 in. was used at the center of the roadway, and the excess fabric was cut along each edge of the roadway. The Mirafi 140 fabric was placed next. The fabric, which was in a roll 328 ft long and 14 ft 9 in. wide, was first sawed to a width so that two lanes would have 24 ft 6 in (Photo 46). The test area was sprayed with asphalt tack at the rate of 0.18 gal/sq yd. Fabric laydown was accomplished by attaching a 1-in.-diam support pipe and hand-held brake devices to the fabric roll and adjusting each brake to provide uniform drag. The fabric was then placed by unrolling about 20 ft of fabric, stretching it taut and

wrinkle free, and lowering it into the asphalt (Photo 47). All spray applications were begun and ended on building paper (Photo 48). The Petromat (Paving-Grade fabric weighing 4.2 oz/sq yd) was placed next. Phillip's Fibers Corporation also manufactures a 6- and 8-oz Paving-Grade Petromat fabric. The fabric was in a roll 300 ft long and 12 ft 6 in. wide and was placed with a small tractor designed and equipped to lay fabric (Photo 49). The test area was sprayed with asphalt tack at the same rate as had been applied for the Bidim C-22 fabric (between 0.2 and 0.25 gal/sq yd). The tractor is positioned with the roll of fabric on the front and proceeds to lay the fabric in the fresh tack material fairly rapidly (Photo 50). The fabric can be laid fairly wrinkle free with an experienced operator on the tractor (Photo 51). Placement of all fabric sections was completed by early afternoon. There was some excess Petromat fabric, and this was placed in the area indicated in Figure 5 between telephone poles Nos. 1 and 2. All fabric areas were rolled with a pneumatic-tired roller after completion; and with the high air temperatures, the asphalt tack was evident on the surface of the fabric (Photo 52).

42. Arizona Refining Company had a tanker trailer available on the site loaded with asphalt-rubber mixture, which was transferred to the distributor truck after the truck was cleaned of the tack material. The material in the truck was Wilmington Asphalt, AR-4000, with about 3 percent extender oil added, mixed with rubber. The mixture was heated to about 400°F and applied on the test areas at a rate of about 0.65 gal/sq yd. The cover aggregate, which had gradations of 100 percent passing 1/2-in. sieve, 99.0 percent passing 3/8-in. sieve, 59.0 percent passing 1/4-in. sieve, 1.0 percent passing No. 8 sieve, and 0.1 percent passing No. 200 sieve, was applied at the rate of about 40 lb/sq yd. The cover aggregate was not heated and contained considerable surface moisture from rain on the stockpile. The aggregate dried quickly and appeared to be well embedded in the asphalt-rubber membrane. The U. S. Rubber material was placed by Arizona Refining Company in about an hour, but the contractor had to wait until late in the evening for the Sahuaro distributor truck, which had been delayed in coming from a job at Gunnison, Colorado. The roadway had received a light tack of SS-1 emulsion earlier

in the afternoon on the areas where Sahuaro asphalt rubber was to be placed. The tack was also placed over the areas of the roadway that did not have test materials. Immediately prior to placement of the Sahuaro asphalt rubber, it rained for about 30 min. Following the rain, the test areas were swept with a power broom to remove free water from the surface (Photo 53). The asphalt-rubber mixture was applied at a rate of about 0.61 gal/sq yd and chipped with the cover aggregate, which was damp from sitting in uncovered trucks during the rain, at a rate of about 40 lb/sq yd (Photos 54 and 55). The area was rolled immediately with a pneumatic-tired roller, and the edge joint broomed prior to application of the next lane (Photo 56). Application of the Sahuaro material completed placement of all test items. The 1-1/2-in.-thick asphaltic concrete overlay was placed on the south lane of the roadway on the morning of 13 July 1978 (Photo 57). This work coincided with an overlay that was being placed on State Highway 115, and the same mix was used at both locations. Both lanes were paved up to the tank crossing (Figure 5) before proceeding further west on Wilderness Road. Paving over the test items presented no problems. All paving was completed on 14 July 1978.

PART IV: ANALYSIS OF PERFORMANCE

43. It is planned to monitor the performance of the various test materials for a period of several years by making annual inspections of the test areas. The progression of reflective cracking will be followed by photographing selected areas in each test section. Prior to the application of the test materials, an area 25 by 25 ft was selected in each test section (see Figures 1-5 for location), and a photograph made of this marked off area. The cracks in this marked off area were plotted on a transparency so that a detailed record of all cracks was recorded. After the test areas have gone through the first winter season (a 6-month inspection period) and yearly thereafter, a photograph will be made of the same marked off area, and progression of cracking will be transferred to the transparency. This will make it possible to determine if the existing cracks are reflecting, if new cracks have formed as a result of wrinkles or laps in the fabric during construction, or from other causes. As noted in the photographs presented in this report for the 6-month inspection period, the photographers obtained from each installation failed to duplicate the same view as shown for the initial photograph. For all future inspections, it is planned to use a photographer from WES, who will take the pictures for all test sites. The cracking that may occur will also be observed in the entire test section and will be reported on in general terms.

Fort Lewis, Washington

44. In February 1978, approximately 5 months after construction, it was reported by personnel of the Facilities Engineering that distress in the form of ravelling was occurring in the asphalt-rubber chip seal on Second Division Drive, and fine hairline cracks were observed in one of the fabric sections on Faith Avenue. A visit was made to Fort Lewis at that time, and it was found that the asphalt-rubber chip seal placed by Sahuaro on Second Division Drive was ravelling with loss of chips in the traffic wheel paths and turnoffs to parking areas (Photo 58).

Ravelling was occurring in areas where the precoated chips and uncoated chips were used and was worst in the wheel path of vehicles travelling south. A considerable buildup of loose chips was evident at the curb line. The U. S. Rubber chip seal was observed to have an area about 100 ft long along the center line of the roadway where during construction the distributor truck failed to overlap the first spray application and a blank area about 6 in. wide existed (Photo 59). On the south side of Faith Avenue at the transition area between the Mirafi 140 fabric section and the U. S. Rubber section, a crack had developed and fabric was protruding up through the overlay (Photo 60). A core taken in this area indicated that loose cover aggregate from the U. S. Rubber section was not cleaned off the pavement prior to placement of the fabric and the aggregate kept the fabric from bonding to the pavement. A fine hairline crack was found about midway in the Mirafi 140 fabric section on the south side of Faith Avenue and also one on the north side (Photo 61). Cores taken indicated the fine hairline crack was a result of a wrinkle in the fabric and not reflection from a crack in the base pavement.

45. The survey to monitor the performance of the various test sections was made on 2 May 1978. At that time, all loose chips had been swept from Second Division Drive, and except for a few areas where ravelling had occured, the surface appeared to be performing satisfactorily (Photo 62). No additional ravelling in the Sahuaro test areas had occurred since the visit in February. The U. S. Rubber test area had only the construction deficiency at the center line. The condition of test areas on Faith Avenue was the same as was observed in February. No new cracks have developed in the Mirafi 140 sections. One crack was observed in the control section on the north side of Faith Avenue (Photo 63). None of the cracking observed had occurred in the selected photographic areas. Photographs 64-76 show the crack condition of the pavement prior to overlay and 6 months after the overlay was placed. The transparencies located in the back cover of this report present a clearer picture of the cracking pattern than can be seen in the photographs.

Fort Stewart, Georgia

46. The overlay was placed on the apron at Fort Stewart on 28 October 1977 and on 31 October 1977. It was reported that after placement of the overlay cracks were observed to have occurred in the Mirafi 140 fabric test area. A visit was made to Fort Stewart on 3 November 1977 to check on the cracking that had occurred. All cracks were observed to be perpendicular to the paving and rolling operations (Photo 77). Cores taken in a number of the cracks indicated that they were the result of reflection from cracks in the underlying pavement; however, the fabric was creased in the crack and was not broken. No cracks were observed in any of the other test sections.

47. A visit to observe the performance of the various test sections was made on 11 May 1978. During the interval of the visit in November and May, a tar emulsion slurry seal (an item in the contract that had not been completed by November) had been placed over the apron surface. There were two selected 25- by 25-ft photographic areas in each test section (Figure 3). Photo 78 shows a general view of apron area prior to overlay. Photos 79-88 show the crack condition of the pavement prior to the overlay and 6 months after placement of the overlay. As noted in Photos 85 and 86, cracks in the selected photographic area in the Mirafi 140 section have reflected through the surface.

Fort Polk, Louisiana

48. The survey to monitor the performance of the Petromat fabric on Louisiana Avenue at Fort Polk was made on 1 June 1978. Photos 89 and 90 indicate the crack pattern that existed in the selected photographic areas before placement of the overlay and 6 months after placement of the overlay. As noted in the photographs, two cracks in each 25- by 25-ft area existed from the underlying JC pavement, and these cracks have reflected through the fabric and overlay after the 6-month period. An inspection of the entire roadway indicated about 50 percent of the joint cracking has reflected through the overlay where the Petromat fabric was

placed, and about 10 percent reflection cracking has occurred in the area between Georgia Avenue and Texas Avenue. This area received a 2-in. overlay as compared with a 1-1/2-in.-thick overlay where the fabric was placed.

Fort Devens, Massachusetts

49. The survey to monitor the performance of the various test sections at Fort Devens was made on 7 June 1978. It was reported that the 1977-78 winter was one of the coldest this area has experienced in the past 50 years. Photos 91-107 indicate the crack pattern that existed in the selected photographic areas on the airfield prior to placement of overlay and 6 months after the placement of the overlay. No cracking was noted in the selected areas for the 6-month survey. A total of five transverse cracks in the entire length of the NW-SE runway were observed to have reflected for the area treated with the U. S. Rubber asphalt-rubber membrane (Photo 108). On the NW-SE runway (Photo 109), five transverse cracks were observed in the two 200-ft-long control sections. The small gouged area on the N-S runway (Photo 110), in the Mirafi 140 test area, apparently was caused by a locked wheel turn of an aircraft. The overlay slipped on the fabric and formed the resulting depression. Photos 111-115 indicate the cracking pattern for Barnum Road; and as noted, no cracks have reflected in the selected areas. Some cracking was found in the overlay surface of Barnum Road outside of the test areas (Photo 116).

Fort Carson, Colorado

50. Results of the crack survey for the condition of Wilderness Road prior to the placement of the overlay are presented in Photos 117-128 and the corresponding transparencies for these photographs. A survey to determine the performance of the test areas will be made in the spring of 1979, approximately 1 year after placement of the materials.

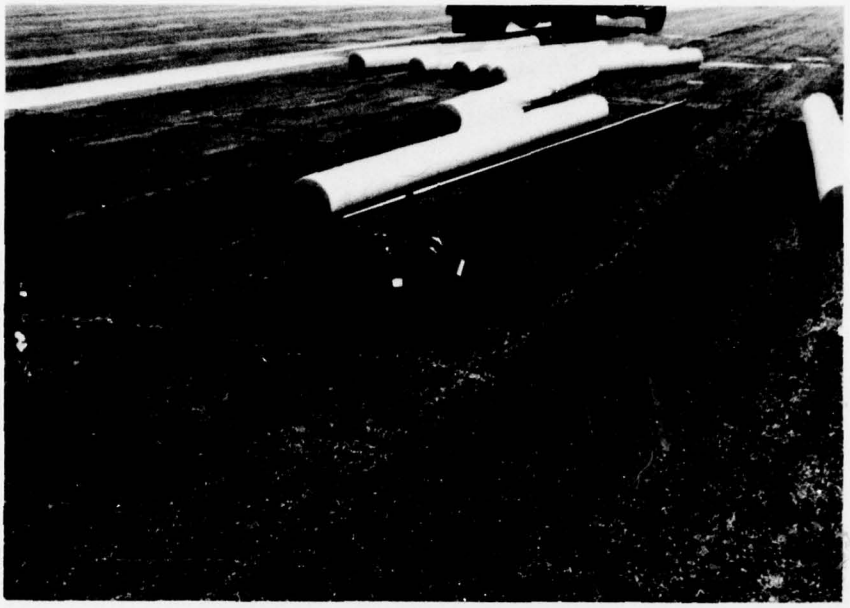


Photo 1. Fort Devens--Mirafi 140 fabric rolls with hand-held tensioning device

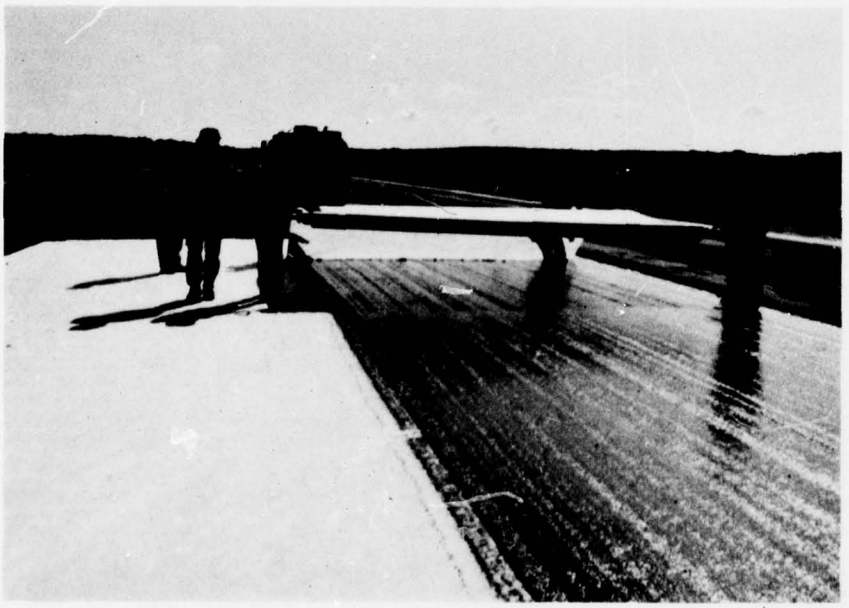


Photo 2. Fort Devens--placement of Mirafi 140 fabric on NW-SE runway

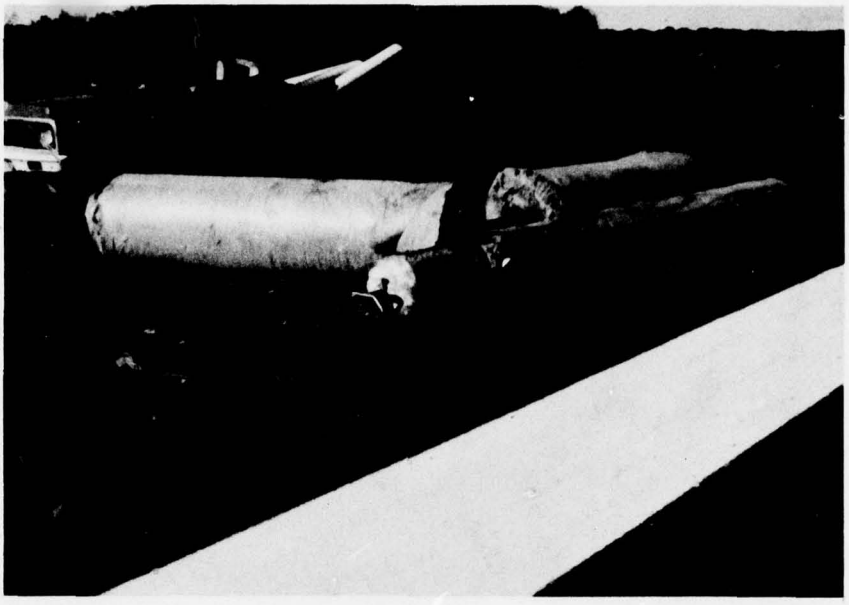


Photo 3. Fort Devens--roll of Bidim C-22 fabric sawed in half to make suitable to handle

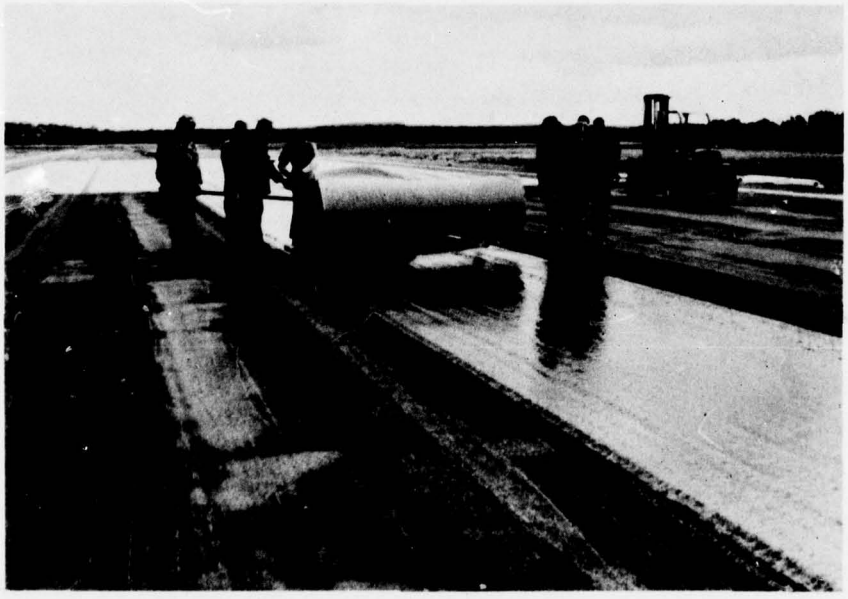


Photo 4. Fort Devens--placement of Bidim C-22 fabric on NW-SE runway; very difficult to place wrinkle free

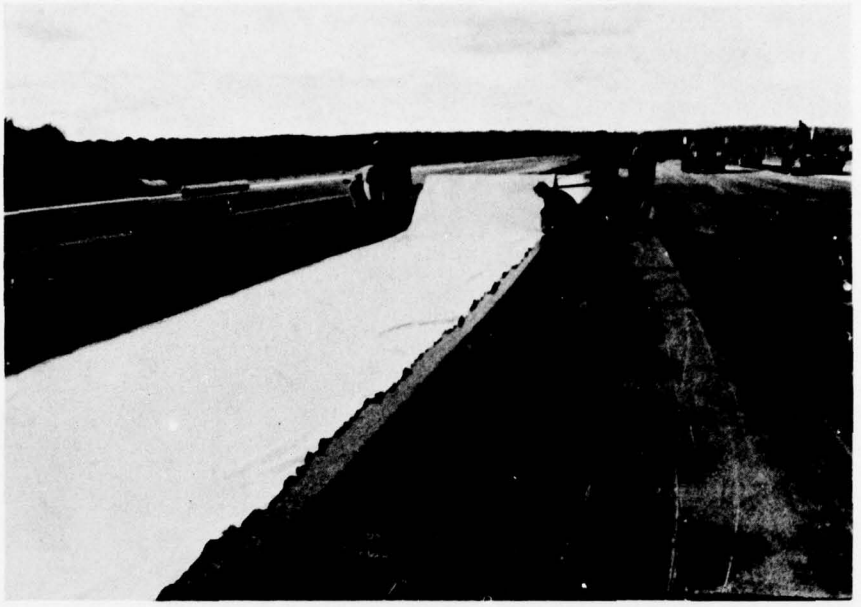


Photo 5. Fort Devens--sawed edge of Bidim C-22 gave a ragged appearance; material smoothed out under roller

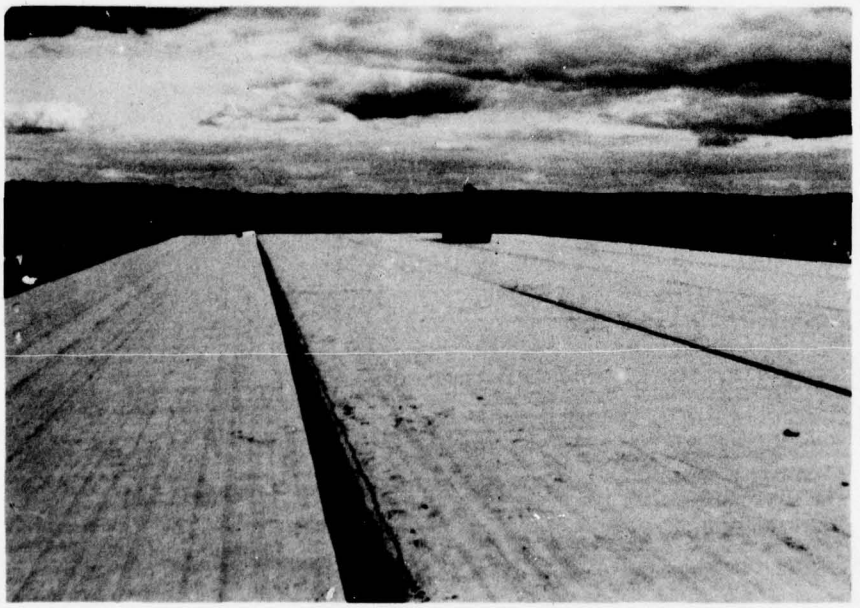


Photo 6. Fort Devens--fabric sections rolled after placement

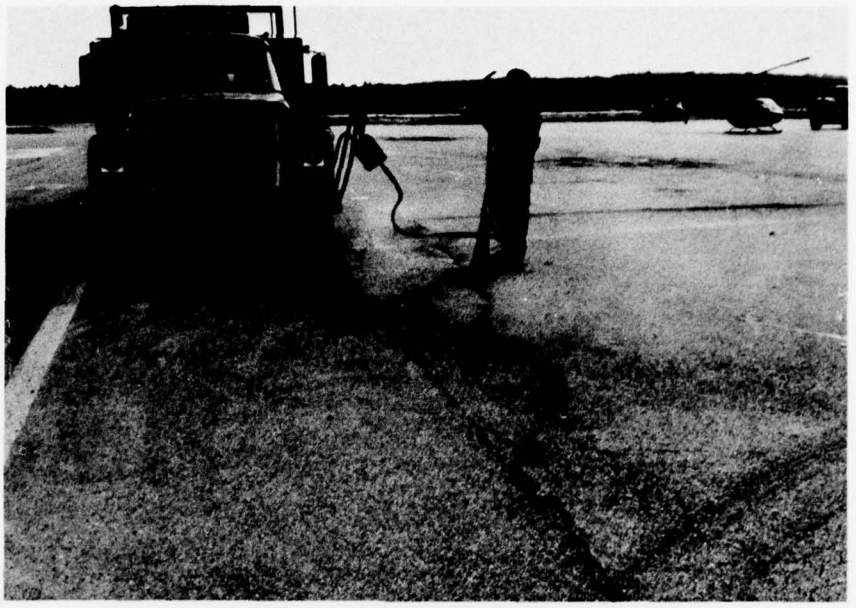


Photo 7. Fort Devens--cleaning of cracks on apron area prior to sealing

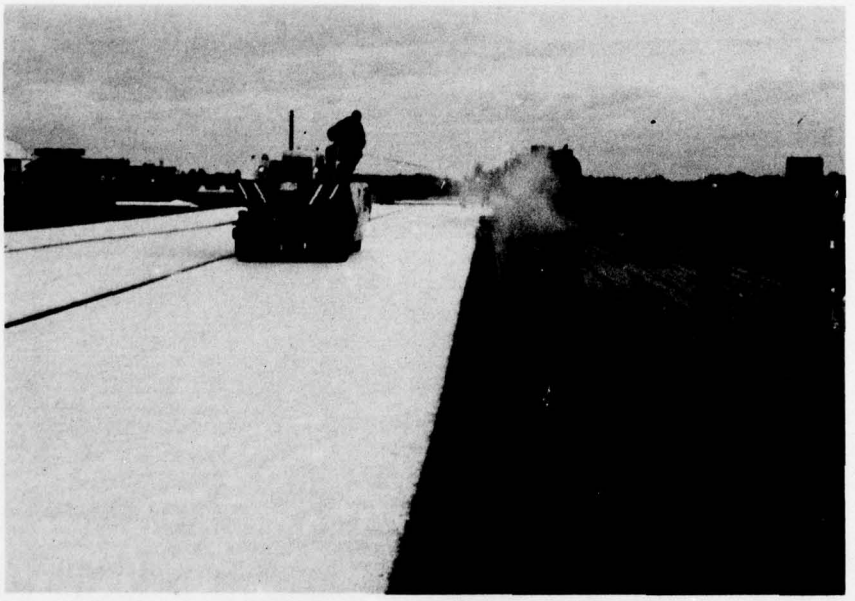


Photo 8. Fort Devens--application of tack on apron area; fabric rolled immediately after placement

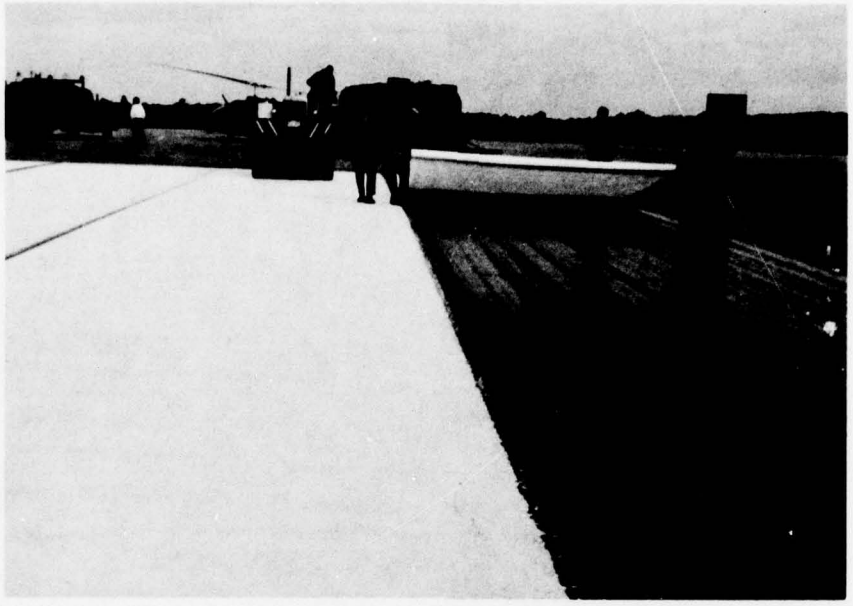


Photo 9. Fort Devens--placement of Mirafi 140 on apron area

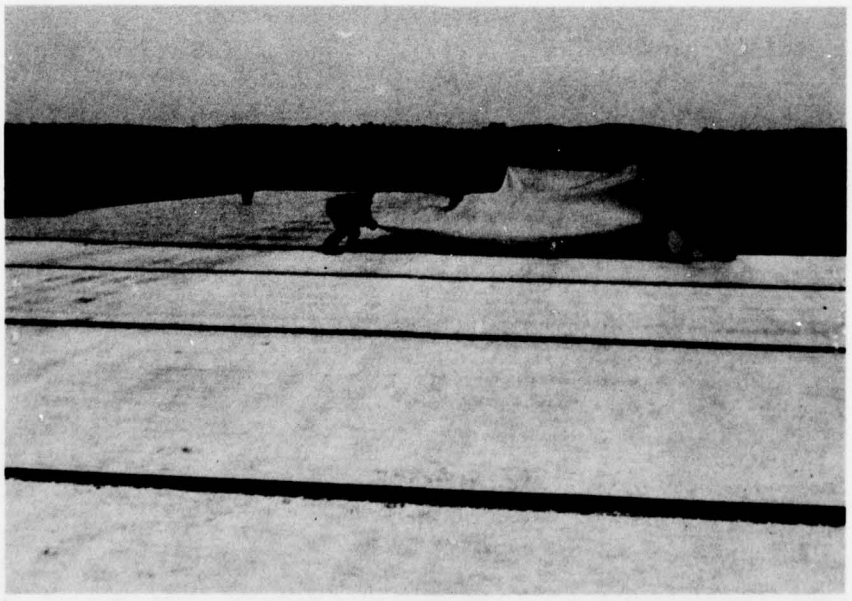


Photo 10. Fort Devens--placement of Bidim C-22 on apron area

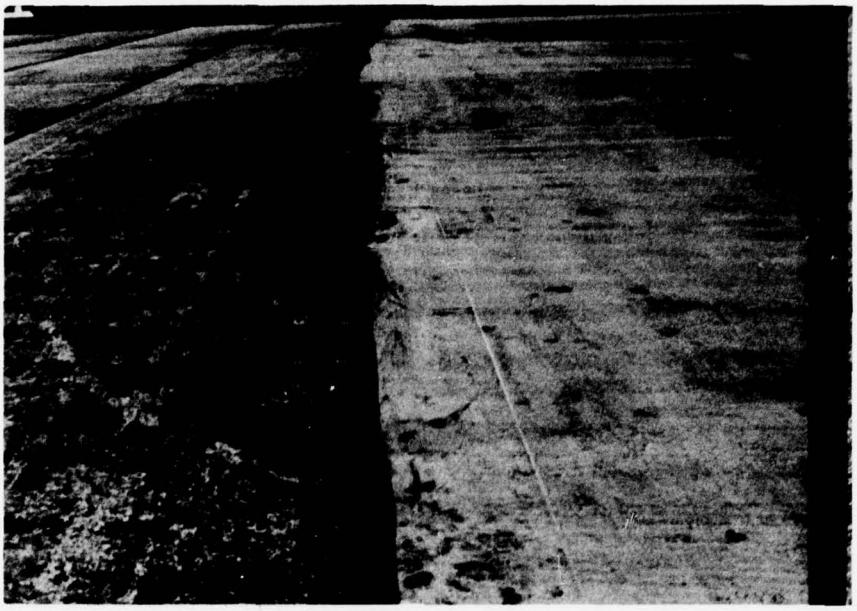


Photo 11. Fort Devens--joints and splices in fabric sections sealed with joint seal material to glue edges to pavement

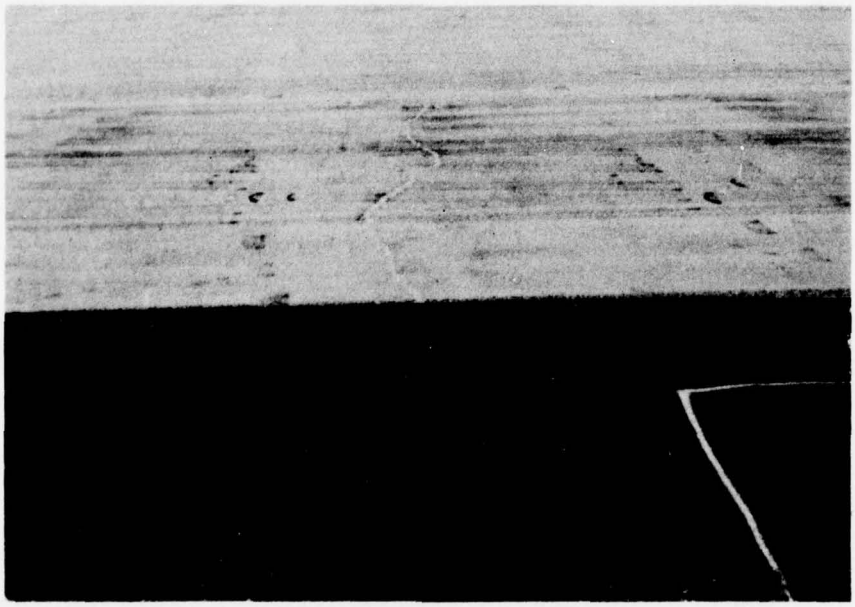


Photo 12. Fort Devens--unsealed crack under Bidim C-22 fabric in apron test area

Photo 13. Fort Devens--fabric test sections on apron;
Bidim C-22 placed in direction of paving;
Mirafi 140 transverse to paving

Photo 14. Fort Devens--addition of rubber to distributor for
application on U. S. Rubber test section on NW-SE runway

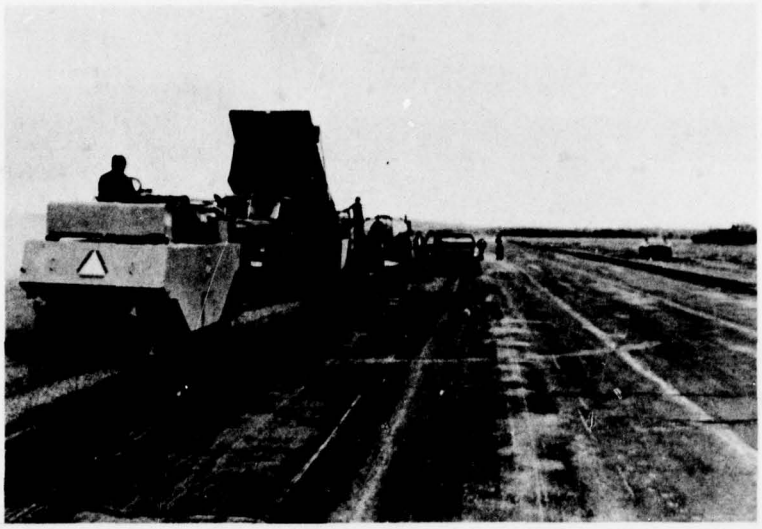


Photo 15. Fort Devens-aggregate spreader and rollers follow immediately behind distributor

Photo 16. Fort Devens--considerable smoke from hot asphalt rubber

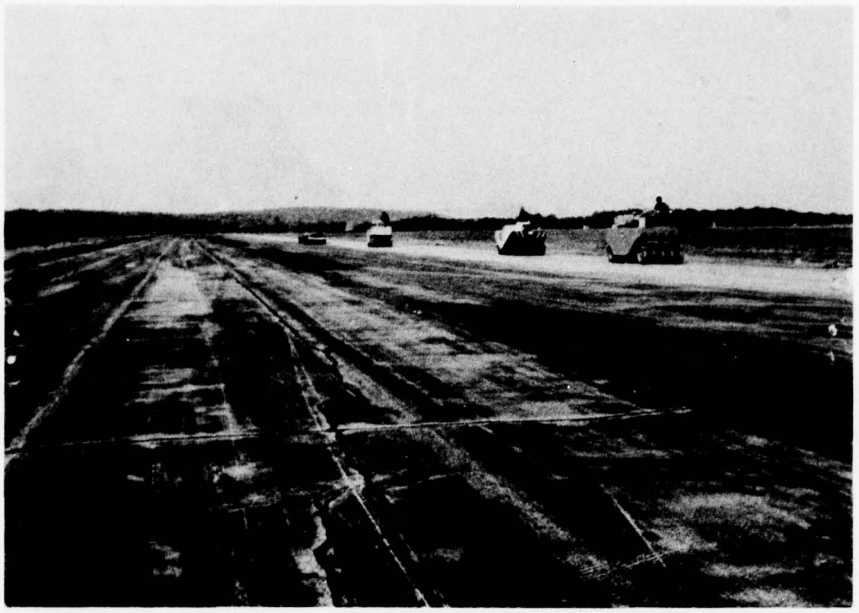


Photo 17. Fort Devens--rolling of chips and sweeping of joint prior to application of next lane

Photo 18. Fort Devens--asphalt rubber and chips after rolling

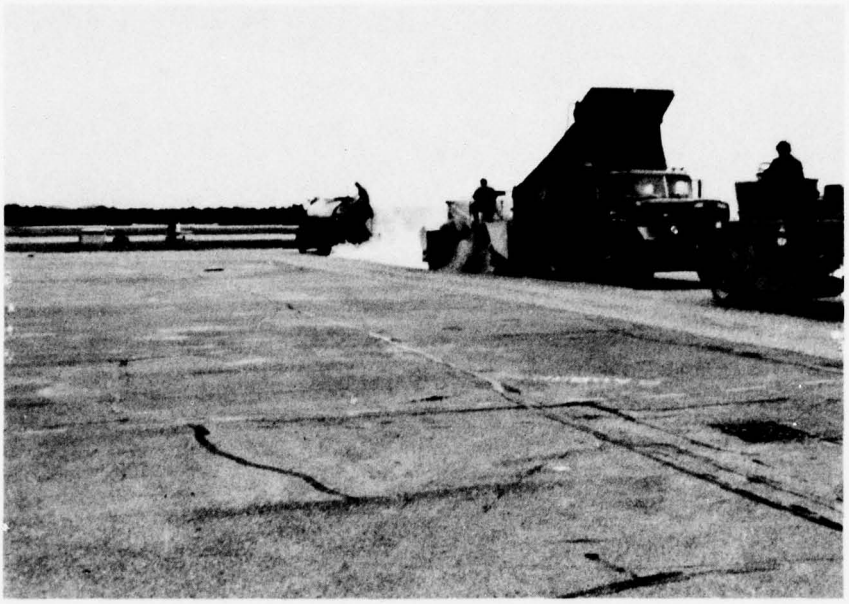


Photo 19. Fort Devens--placement of asphalt rubber and chips, and rolling of U. S. Rubber test area on apron

Photo 20. Fort Stewart--crack pattern from soil-cement base

Photo 21. Fort Stewart--overlap of about 9 in. at joint; note no wrinkling of Bidim C-22 fabric

Photo 22. Fort Stewart--overlap of about 6 in.; note wrinkling of Mirafi 140 fabric

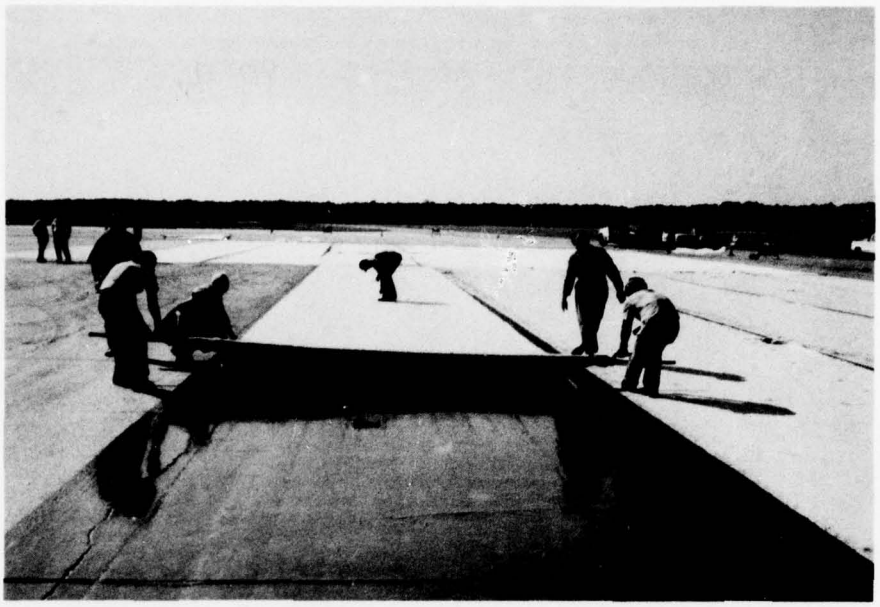


Photo 23. Fort Stewart--placement of Bidim C-22 fabric using hand-held tensioning devices

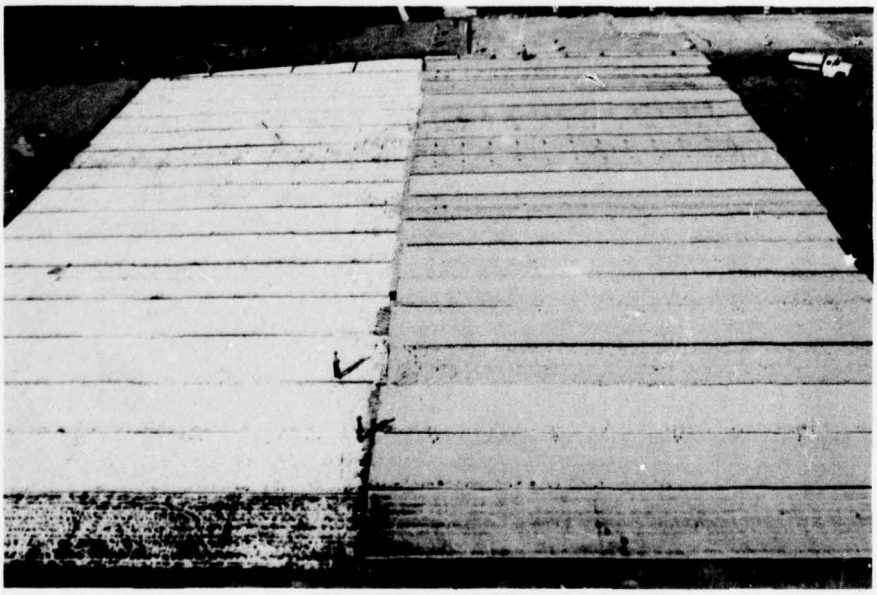


Photo 24. Fabric sections installed; joint between sections sanded to prevent roller pickup; lane in foreground where fabric was placed before emulsion allowed to cure; Mirafi 140 fabric on left and Bidim C-22 fabric on right

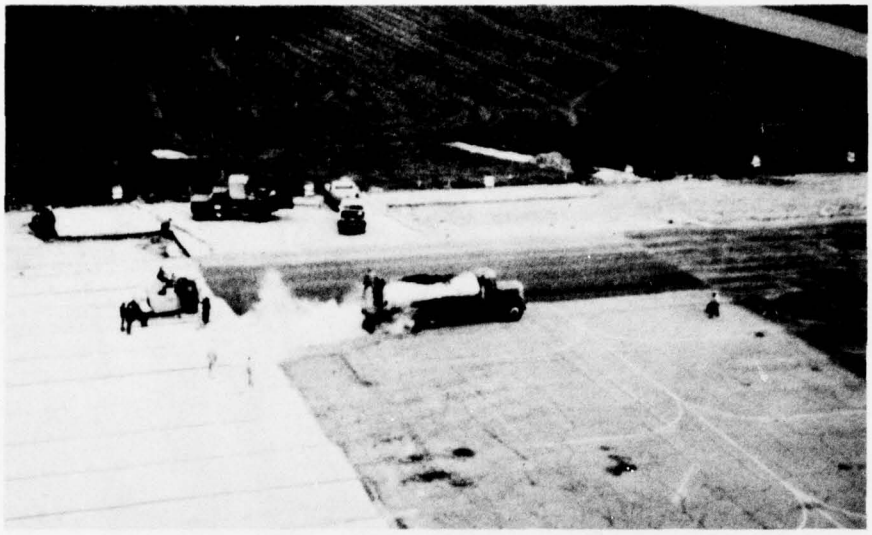


Photo 25. Fort Stewart--Arizona Refining spraying U. S. Rubber test area

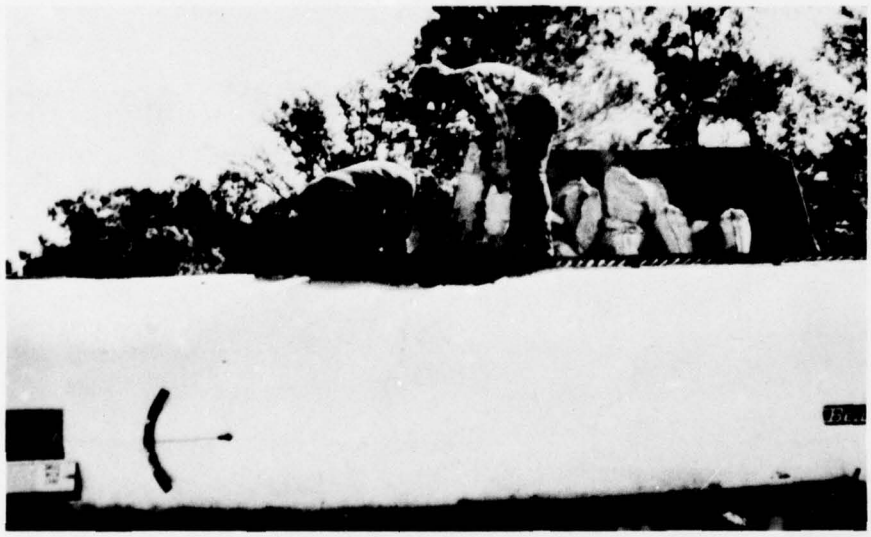


Photo 26. Fort Stewart--loading bags of rubber to Sahuaro distributor truck

Photo 27. Fort Stewart--pumping kerosene into Sahuaro distributor

Photo 28. Fort Stewart--application of light tack coat over test area

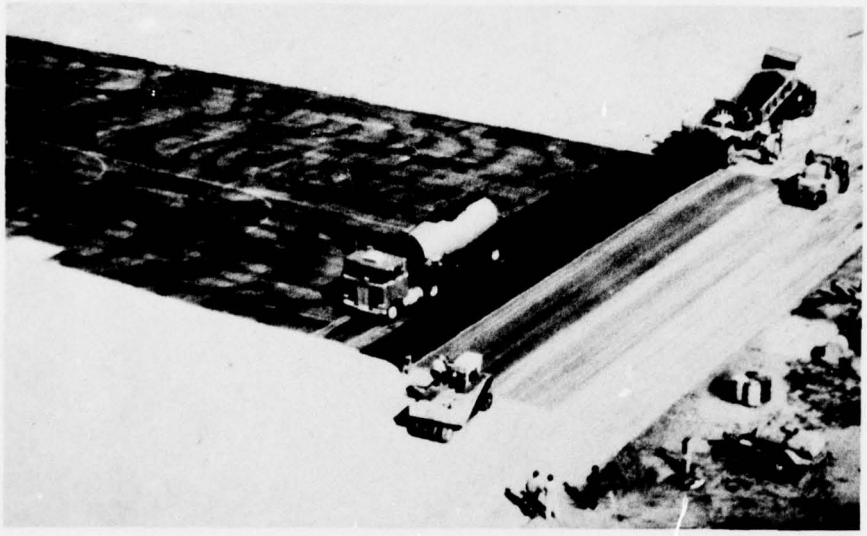


Photo 29. Fort Stewart--application of material on Sahuaro test section

Photo 30. Fort Lewis--type cracking in pavement surface on Second Division Drive

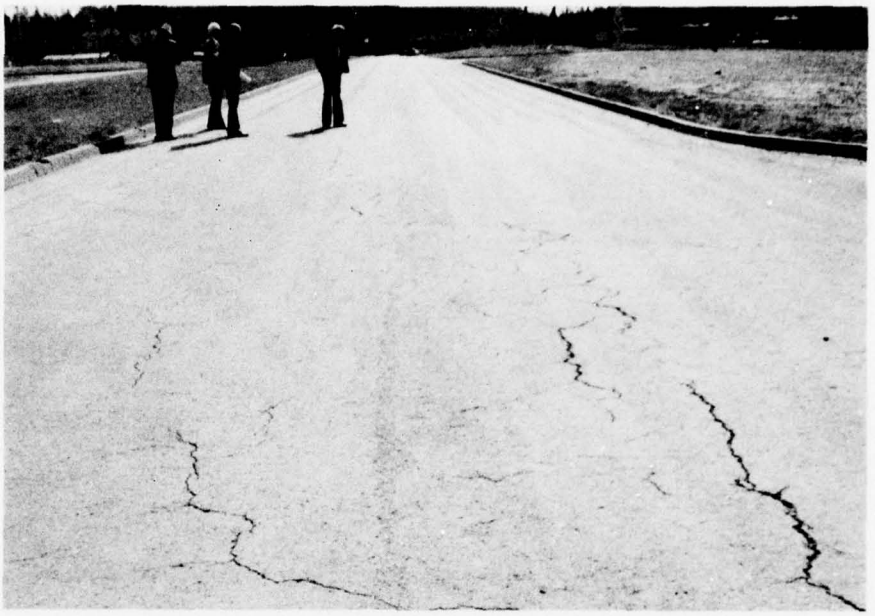


Photo 31. Fort Lewis--cracking in pavements on Faith Avenue; most of cracks in localized areas

Photo 32. Fort Lewis--one lane of asphalt rubber and chips on Second Division Drive; joint has not been swept as yet for next lane

Photo 33. Fort Lewis--cracks on Faith Avenue sealed with AR-4000 asphalt

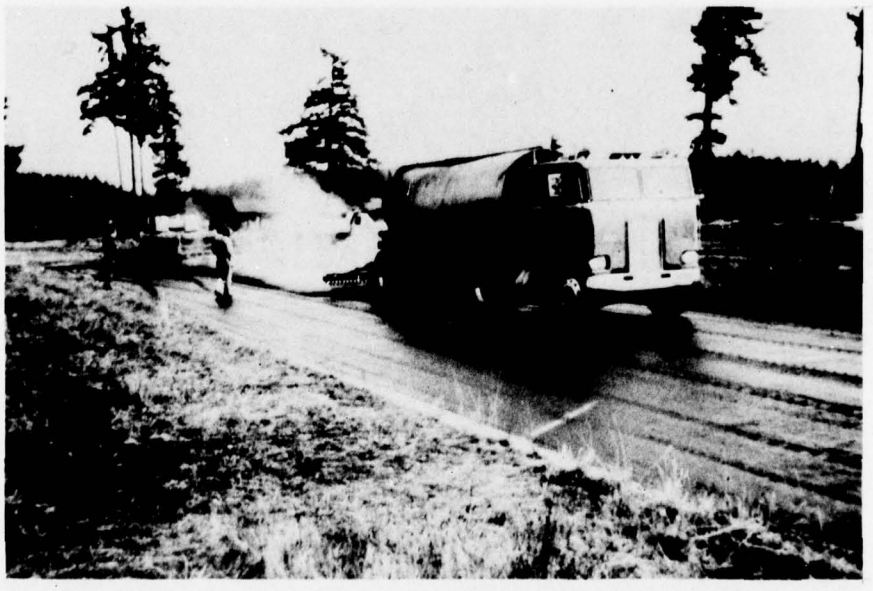


Photo 34. Fort Lewis--application of Sahuaro asphalt-rubber mixture on Faith Avenue

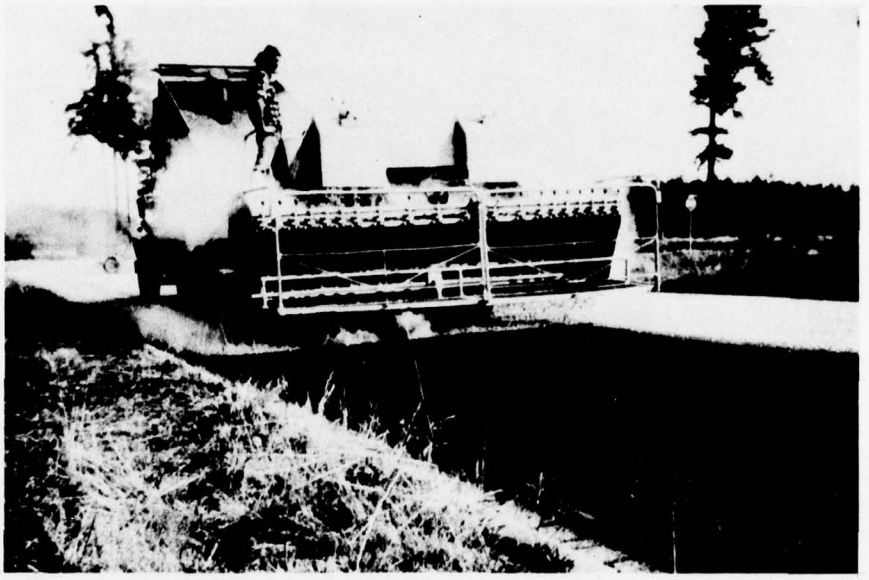


Photo 35. Fort Lewis--placing of uncoated chips on Faith Avenue

Photo 36. Fort Lewis--power broom used to sweep joints of loose aggregate

Photo 37. Fort Lewis--asphalt-rubber membrane peeled up due to wet pavement surface

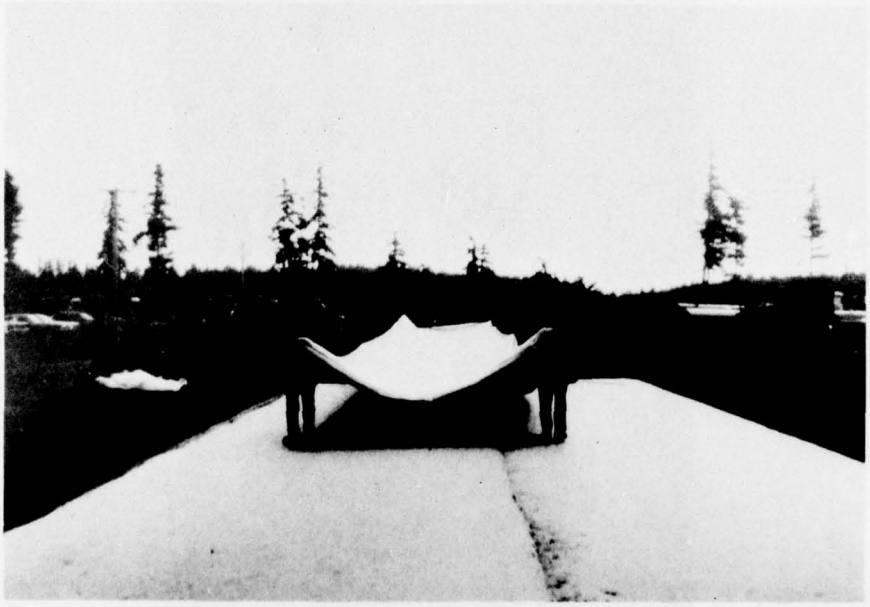


Photo 38. Fort Lewis--Bidim C-22 fabric cut into 105-ft lengths and hand carried in place

Photo 39. Fort Lewis--placement of Mirafi 140 fabric

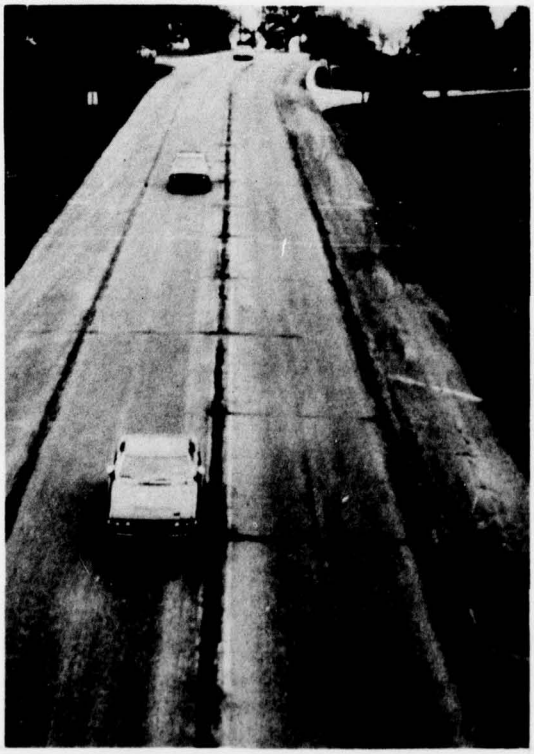


Photo 40. Fort Polk--joints from underlying PCC reflected through AC overlay

Photo 41. Fort Polk--spraying of tack for fabric very poor; nonuniform spray application

Photo 42. Fort Polk--tractor with special attachments for placement of Petromat fabric

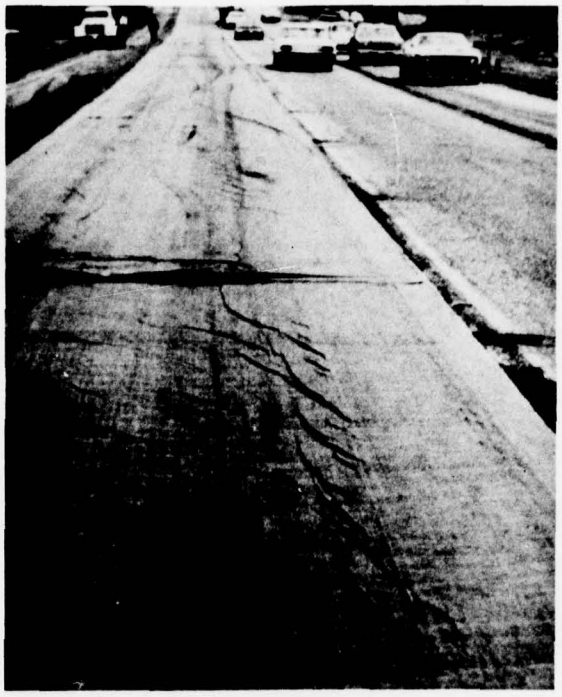


Photo 43. Fort Polk--Petromat fabric placed with considerable amount of wrinkles

Photo 44. Fort Carson--application of tack very light, about 0.15 gal/sq yd

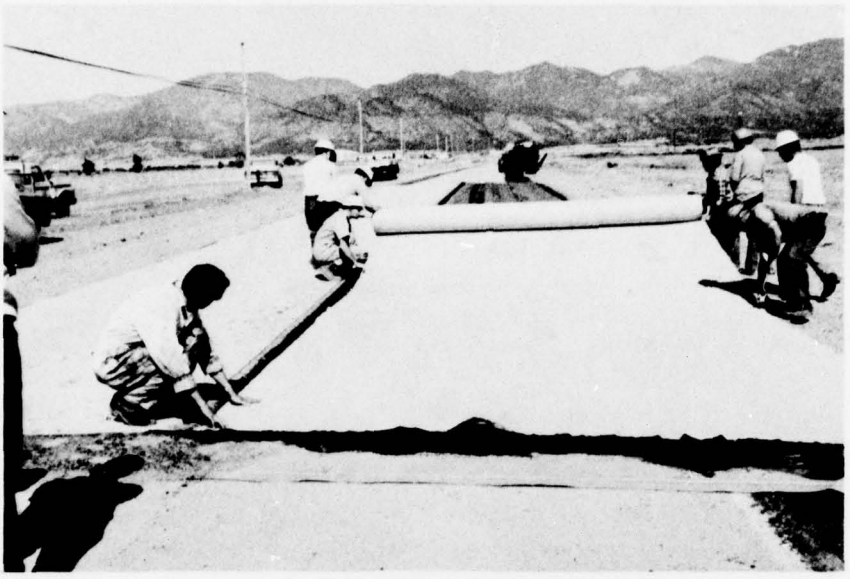


Photo 45. Fort Carson--placement of Bidim C-22 fabric

Photo 46. Fort Carson--Mirafi 140 fabric cut to 12-ft 6-in. width

Photo 47. Fort Carson--placement of Mirafi 140 fabric

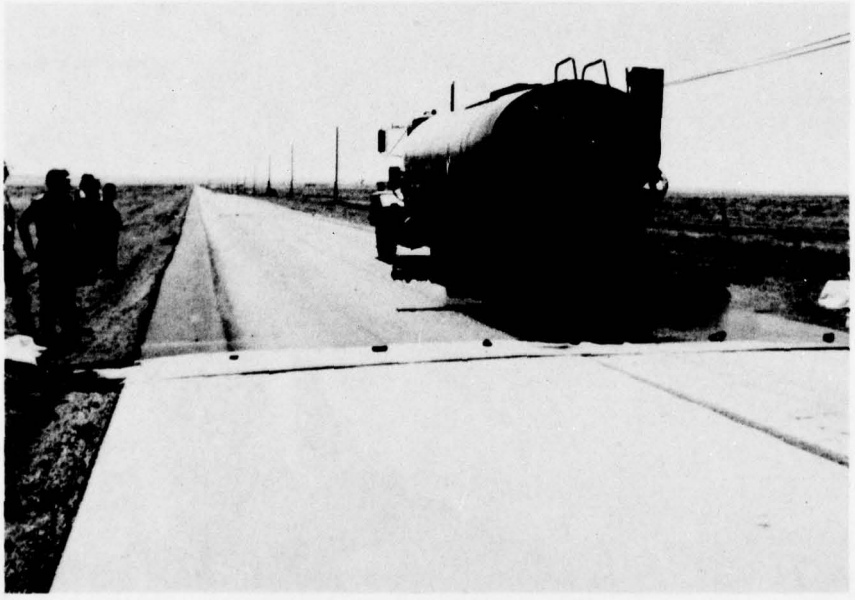


Photo 48. Fort Carson--all spray applications started and ended on building paper

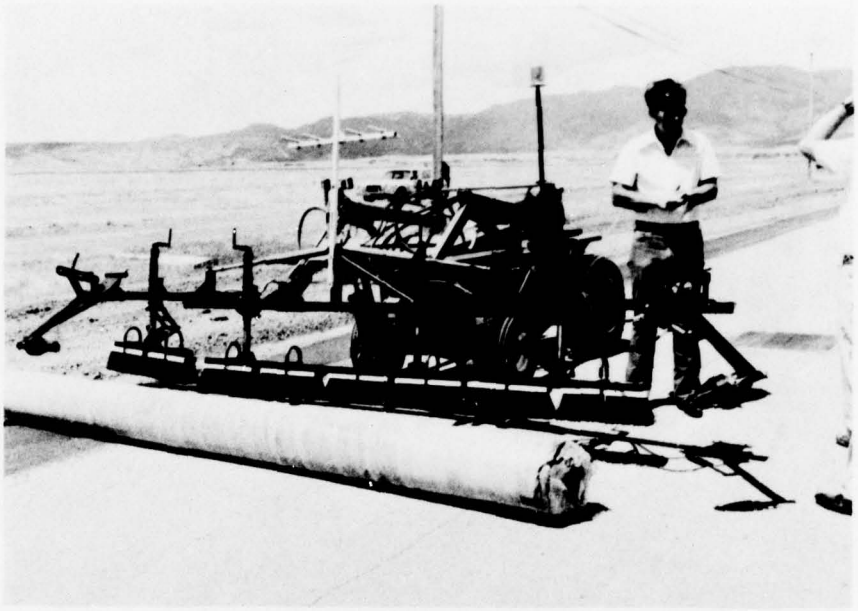


Photo 49. Fort Carson--tractor equipped with special attachments for placement of Petromat fabric

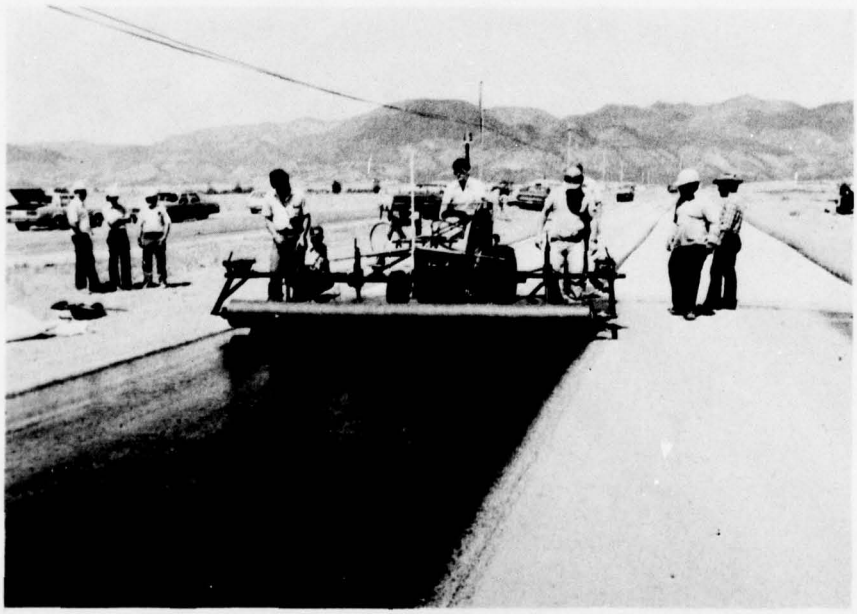


Photo 50. Fort Carson--tractor positioned for placement of Petromat fabric

Photo 51. Fort Carson--Petromat fabric being placed relatively free of wrinkles

Photo 52. Fort Carson--tack material evident on surface of fabric

Photo 53. Fort Carson--brooming surface water from pavement in Sahuaro test area

Photo 54. Fort Carson--application of asphalt rubber by Sahuaro distributor

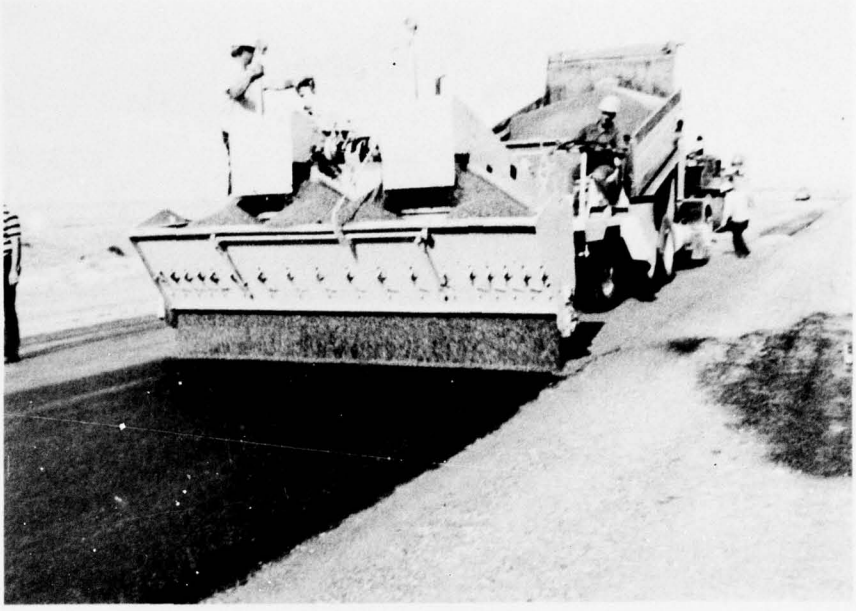


Photo 55. Fort Carson--spreading of damp cover aggregate

Photo 56. Fort Carson--brooming of edge joint and rolling cover aggregate

Photo 57. Fort Carson--overlay 1-1/2 in. thick placed over a fabric section

Photo 58. Fort Lewis--asphalt-rubber chip seal placed by Sahuaro ravelling in traffic wheel paths; note buildup of loose chips at curb line

Photo 59. Fort Lewis--U. S. Rubber chip seal with bare spot at center line; area did not receive rubberized material during construction

Photo 60. Fort Lewis--Mirafi 140 fabric protruded through overlay

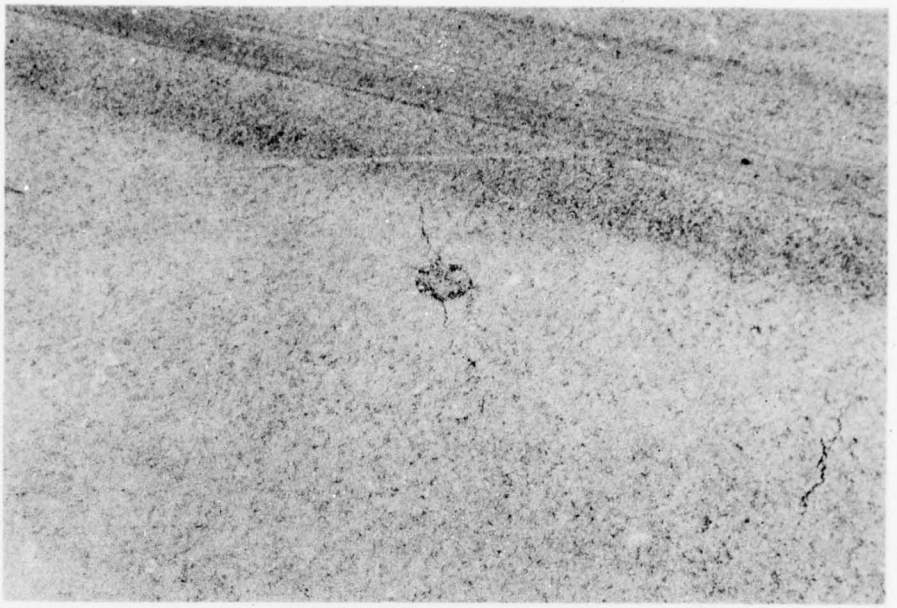


Photo 61. Fort Lewis--fine hairline crack created in overlay by wrinkle in Mirafi 140 fabric

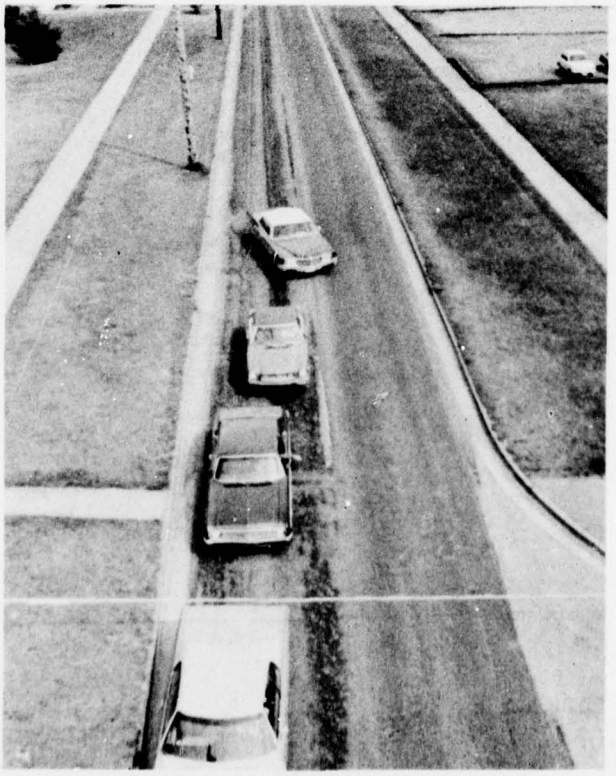


Photo 62. Fort Lewis--general view of Second Division Drive at 6-month inspection

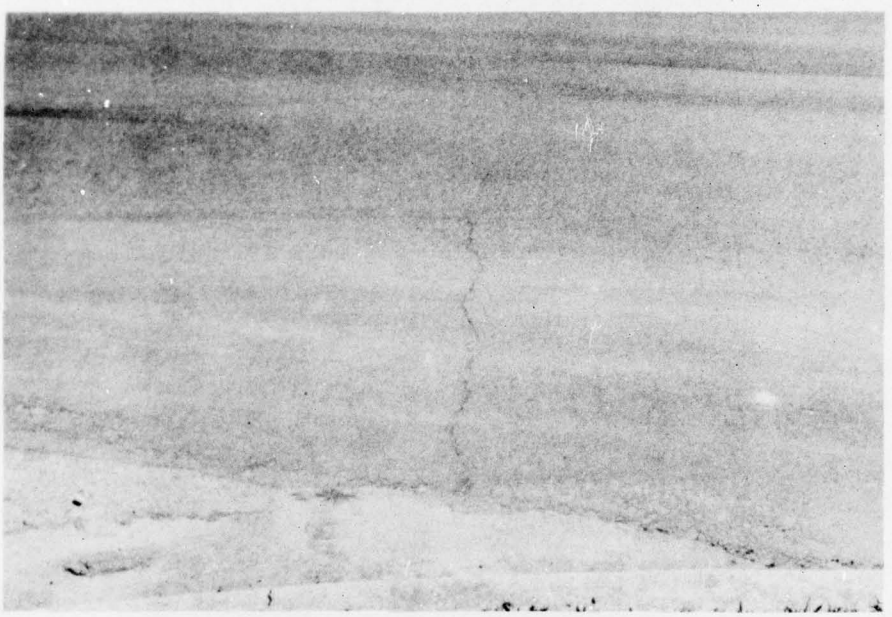
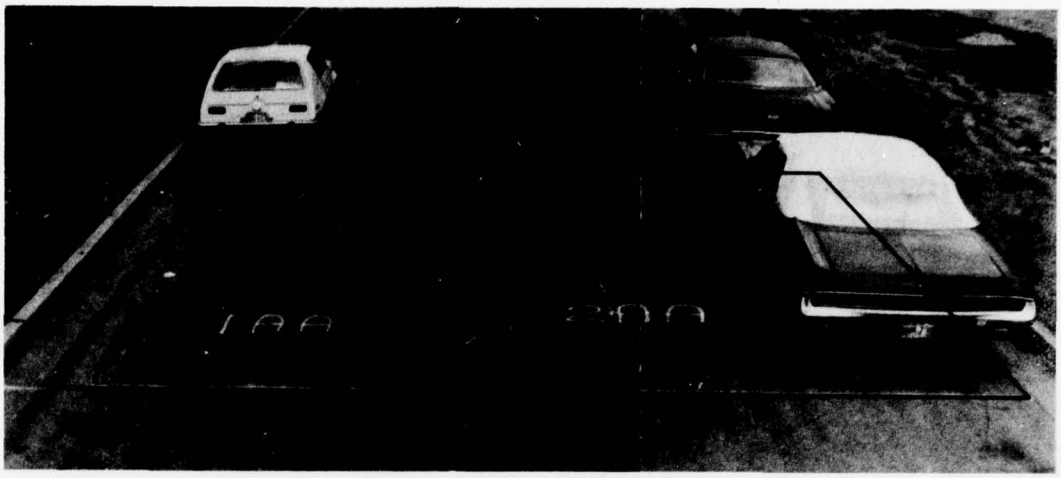
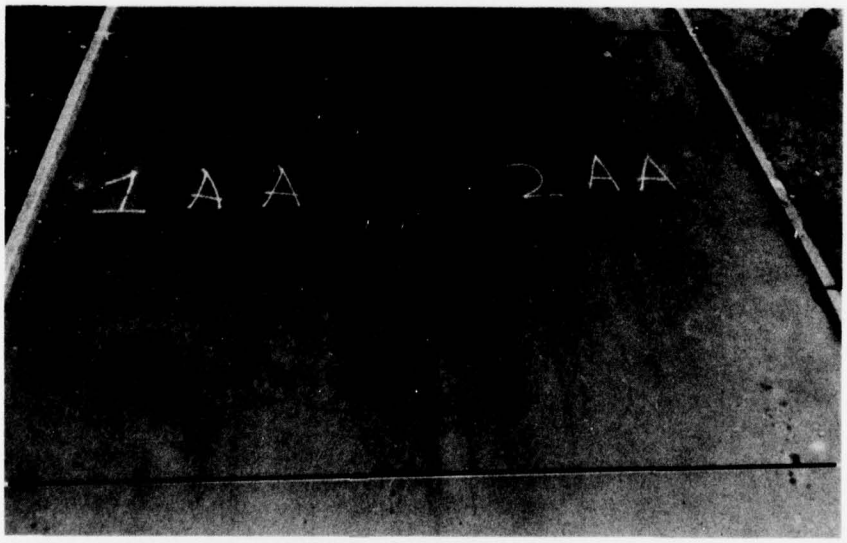


Photo 63. Fort Lewis--reflection crack in control section on north side of Faith Avenue

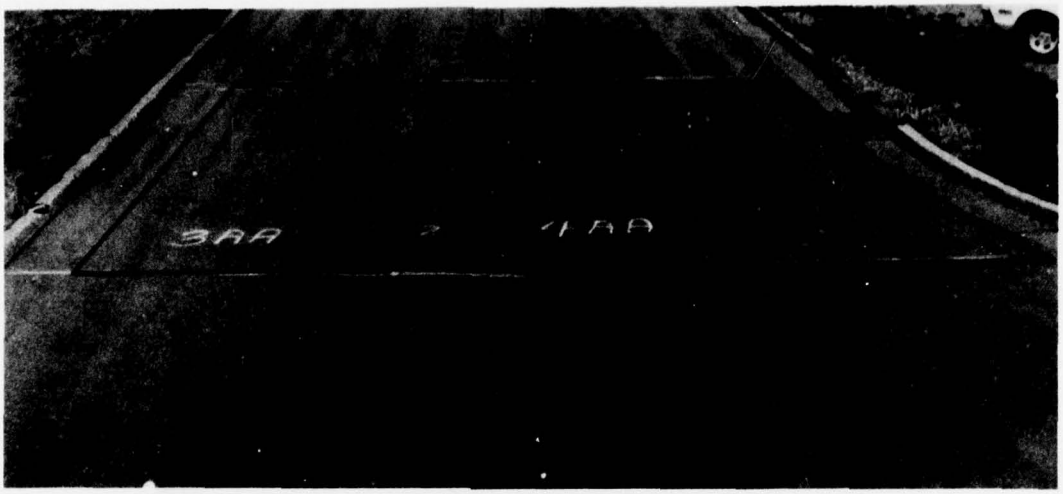


a. Condition of surface prior to overlay

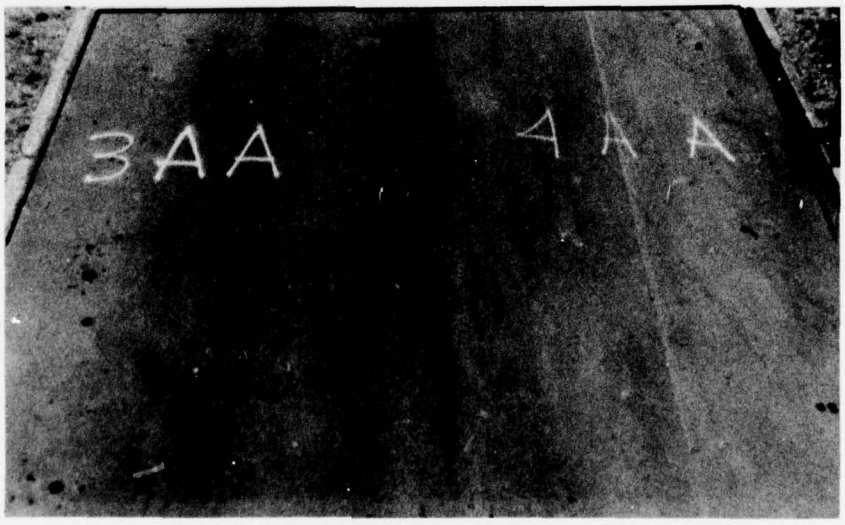


b. Condition of surface 6 months after overlay

Photo 64. Fort Lewis--Bidim C-22 fabric section, south side of Faith Avenue

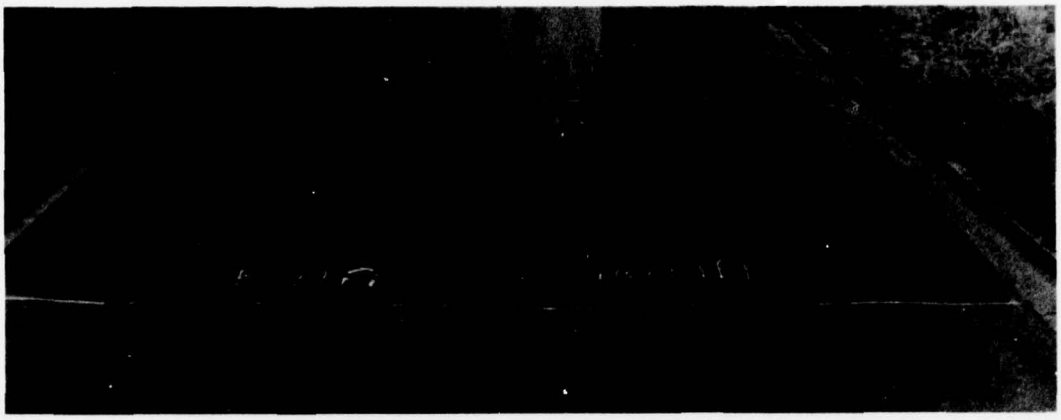


a. Condition of surface prior to overlay

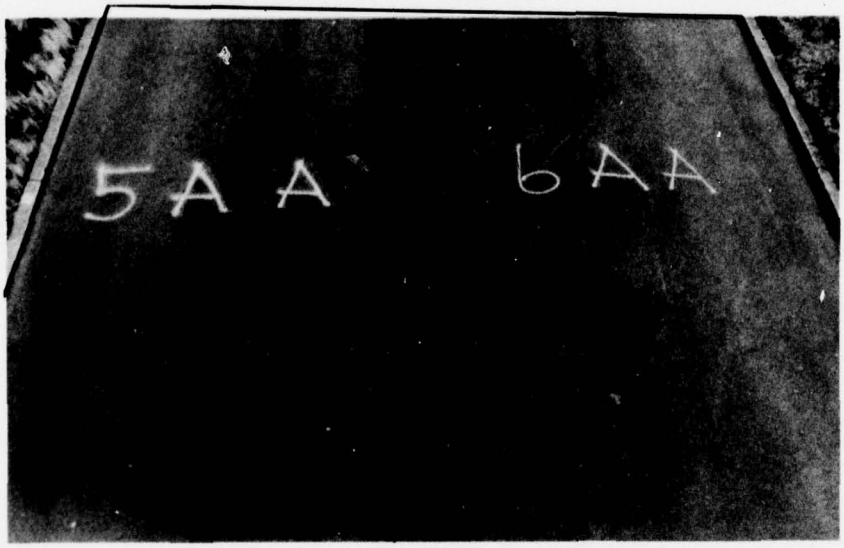


b. Condition of surface 6 months after overlay

Photo 65. Fort Lewis--Sahuaro rubber section, south side of Faith Avenue



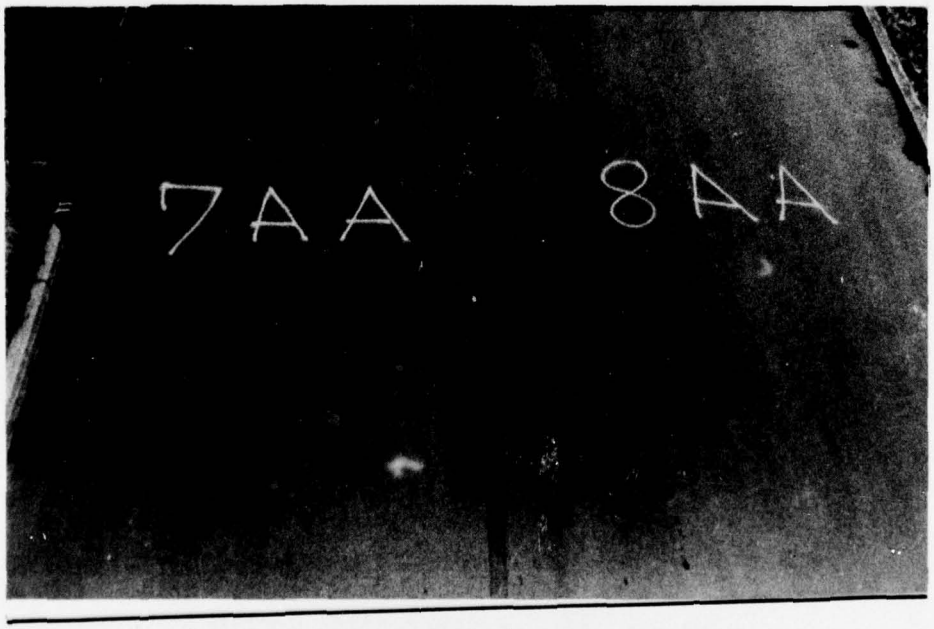
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

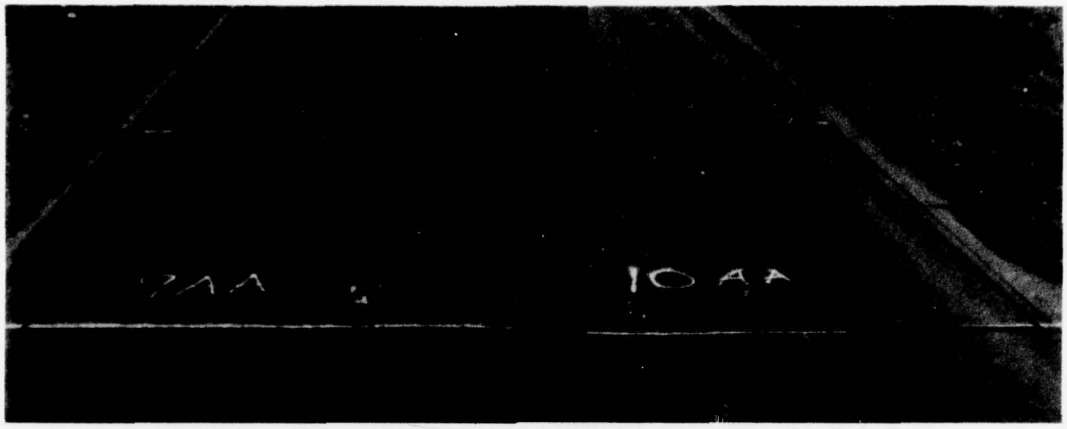
Photo 66. Fort Lewis--control section, south side of Faith Avenue

a. Condition of surface prior to overlay

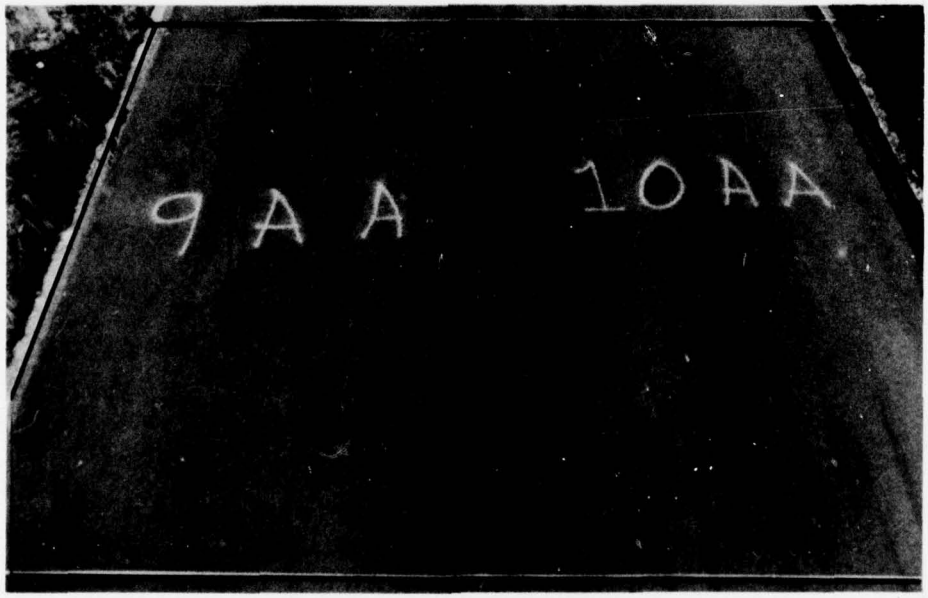


b. Condition of surface 6 months after overlay

Photo 67. Fort Lewis--U. S. Rubber section, south side of Faith Avenue

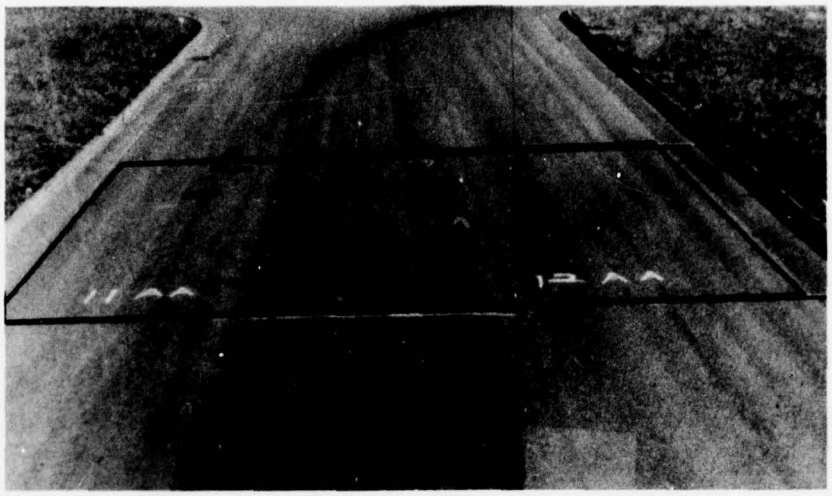


a. Condition of surface prior to overlay

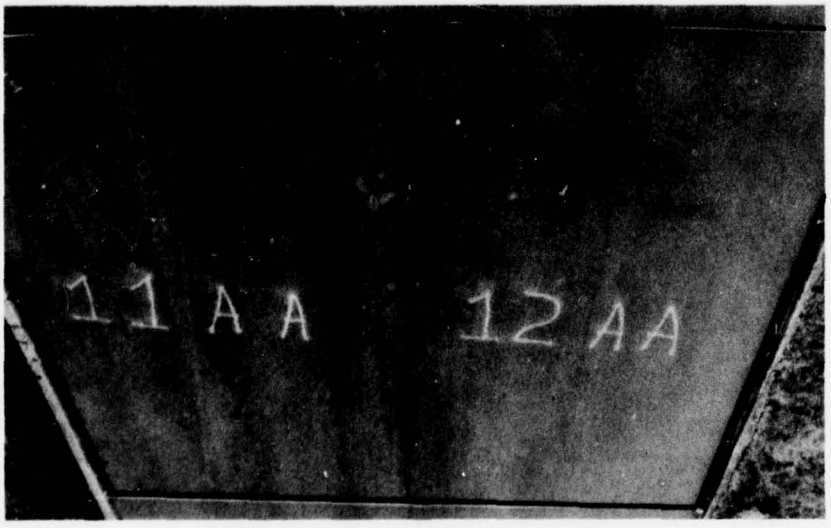


b. Condition of surface 6 months after overlay

Photo 68. Fort Lewis--Mirafi 140 fabric section, south side of Faith Avenue

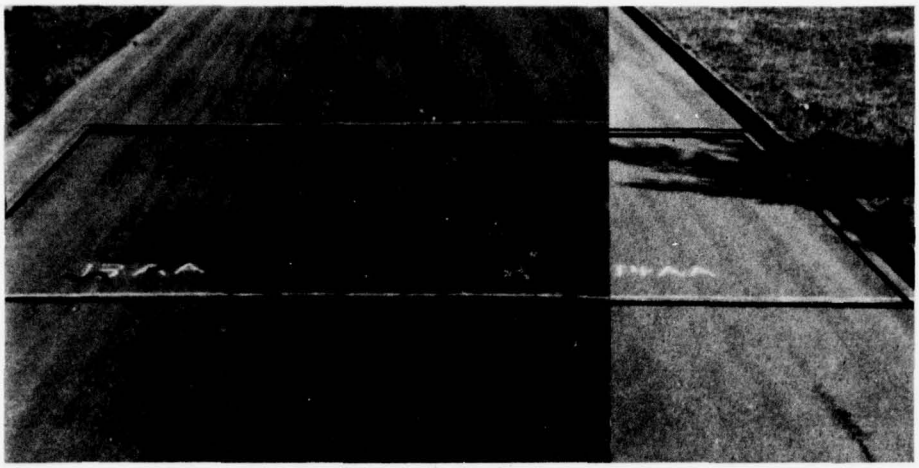


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 69. Fort Lewis--Sahuaro rubber section; north side of Faith Avenue



a. Condition of surface prior to overlay

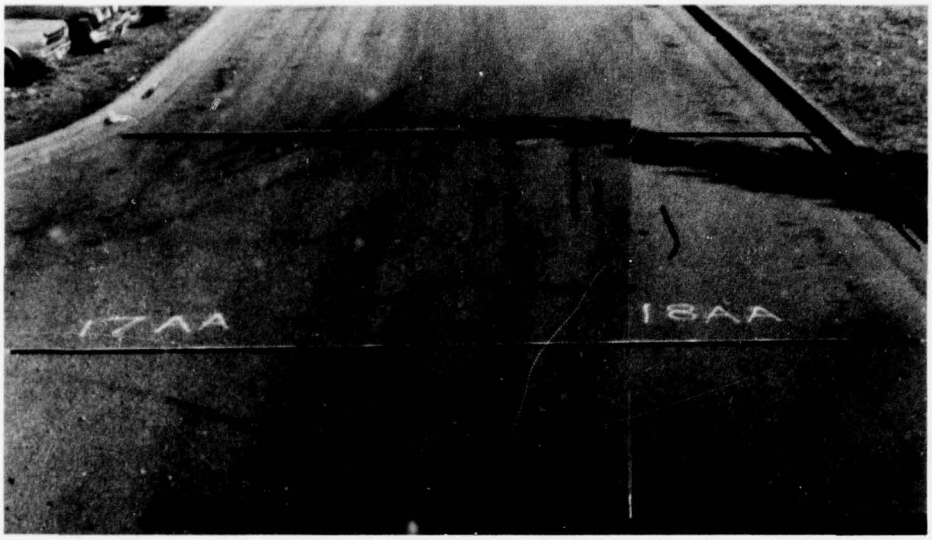
b. Condition of surface 6 months after overlay

Photo 70. Fort Lewis--Mirafi 140 fabric section; north side of Faith Avenue

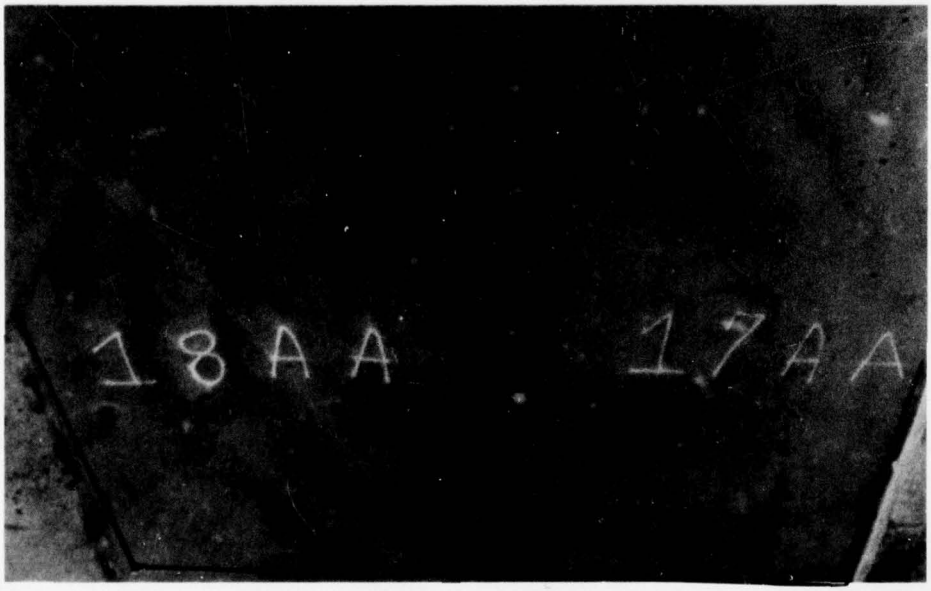
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 71. Fort Lewis--control section, north side of Faith Avenue

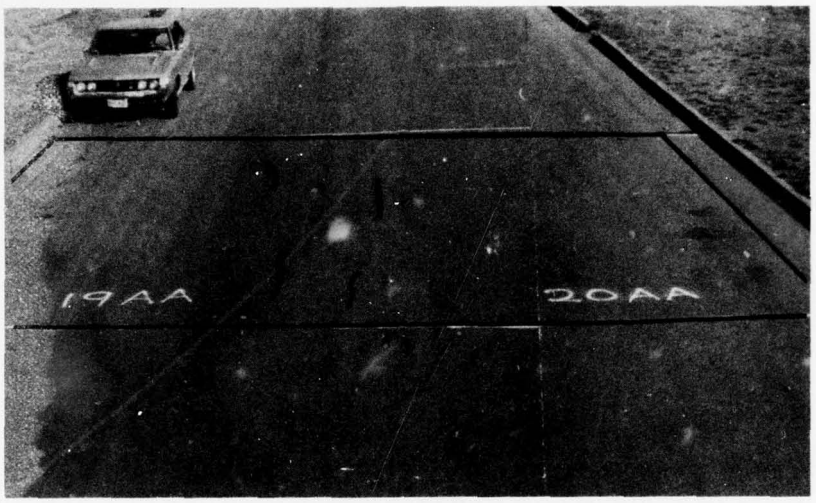


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 72. Fort Lewis--Bidim C-22 fabric section; north side of Faith Avenue

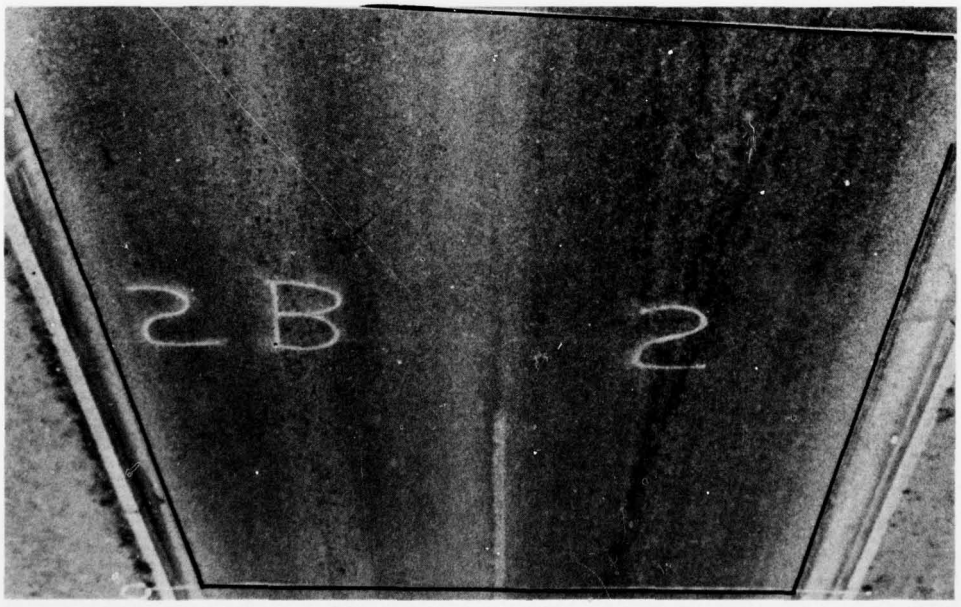


a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 73. Fort Lewis--U. S. Rubber section, north side of Faith Avenue

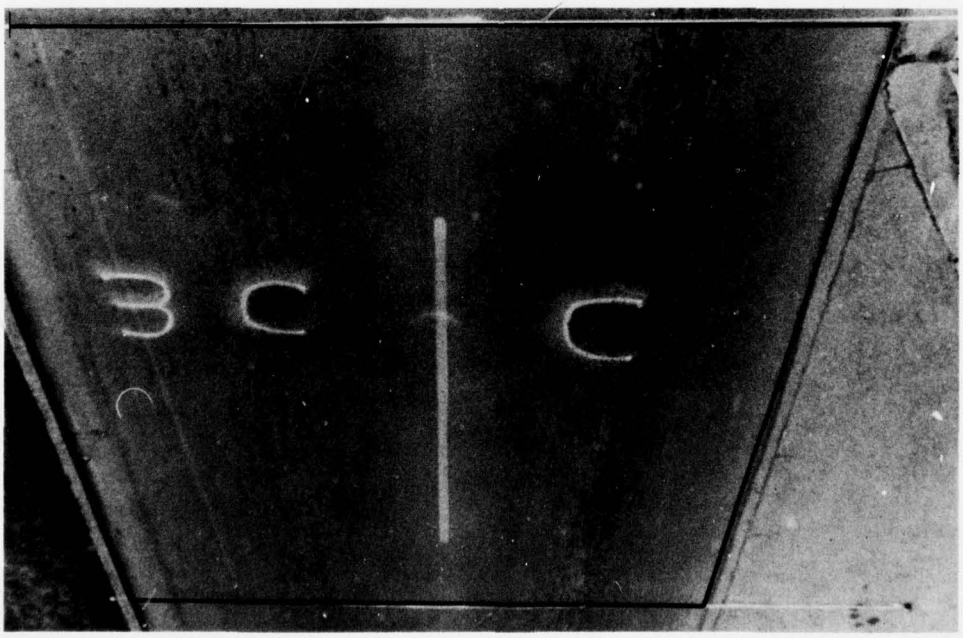
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 74. Fort Lewis--U. S. Rubber section,
Second Division Drive

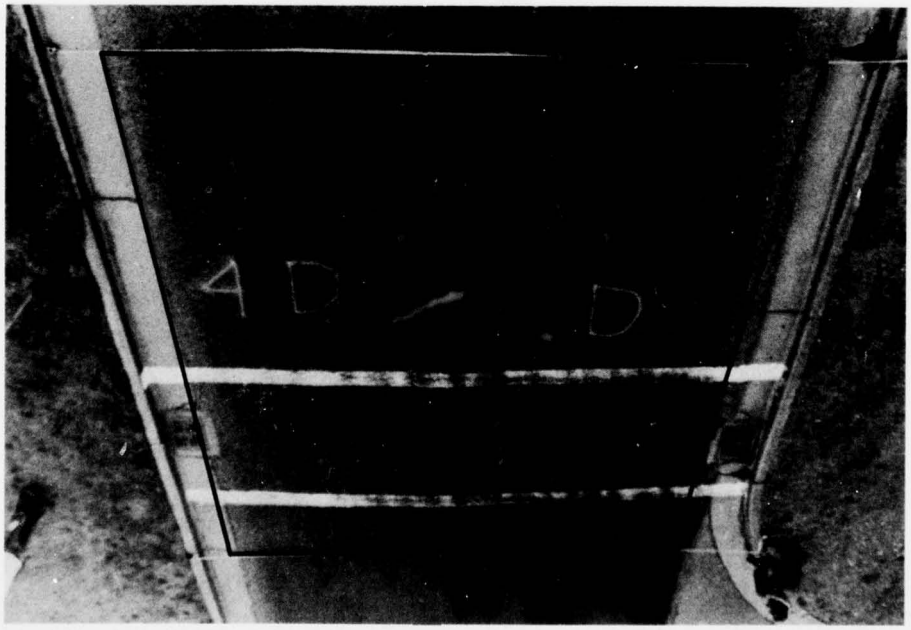
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 75. Fort Lewis--control section, Second Division Drive

a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 76. Fort Lewis--Sahuaro rubber section, Second Division Drive

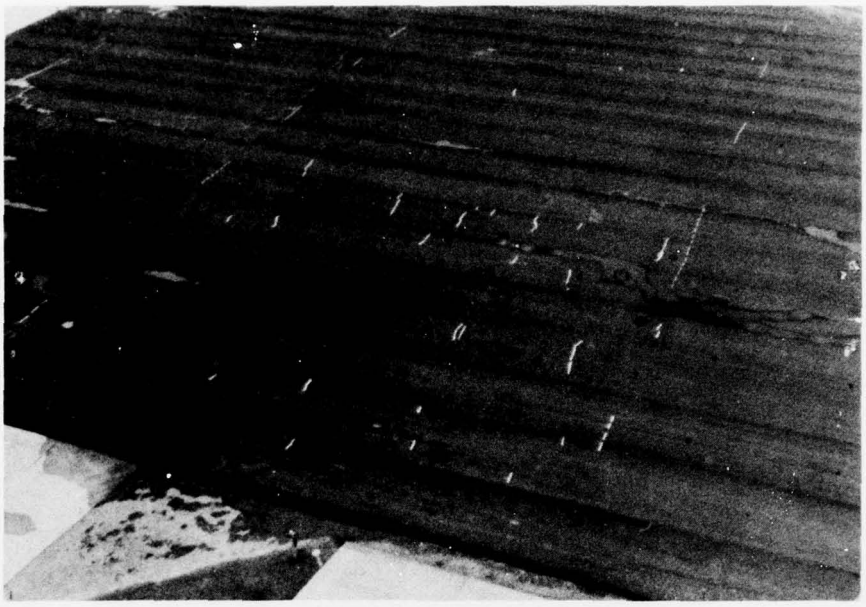
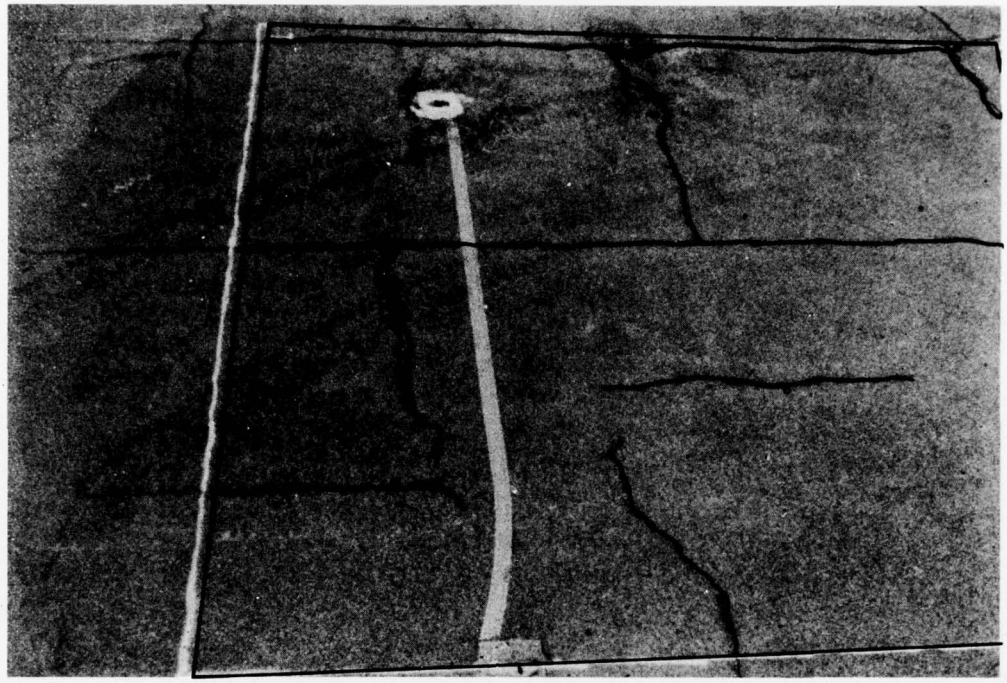
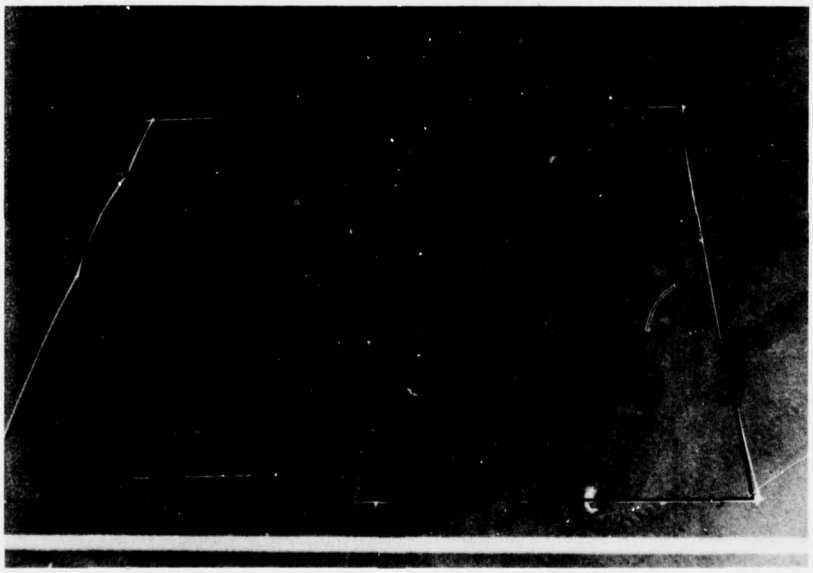


Photo 77. Fort Stewart--cracks in Mirafi 140 section that occurred during construction are outlined with chalk; dashed lines indicate limits of section

Photo 78. Fort Stewart--general view of condition of apron pavement prior to overlay

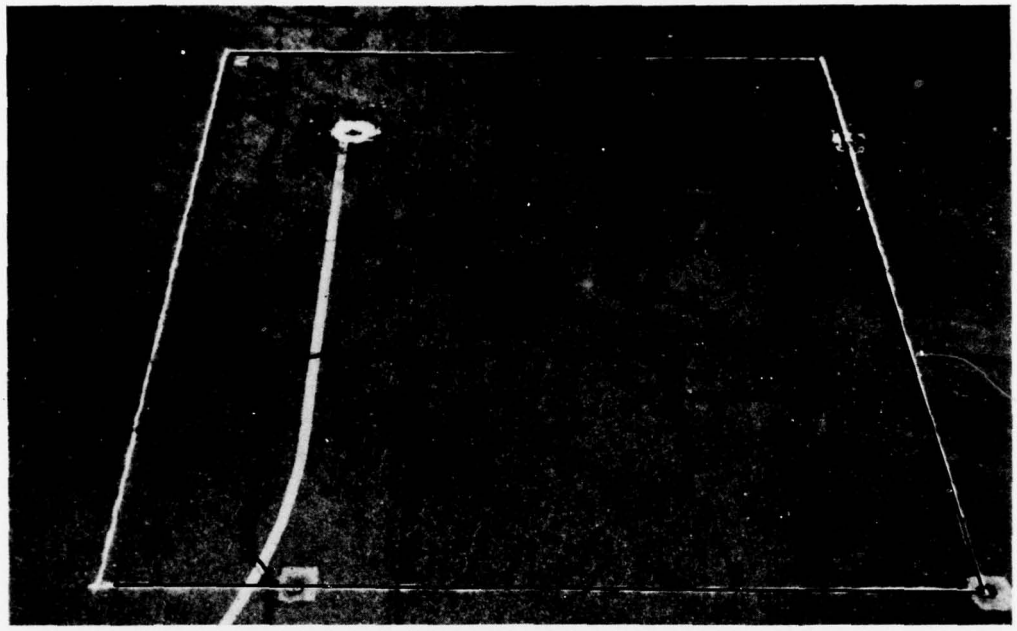


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 79. Fort Stewart--test square in south end of Sahuaro rubber section

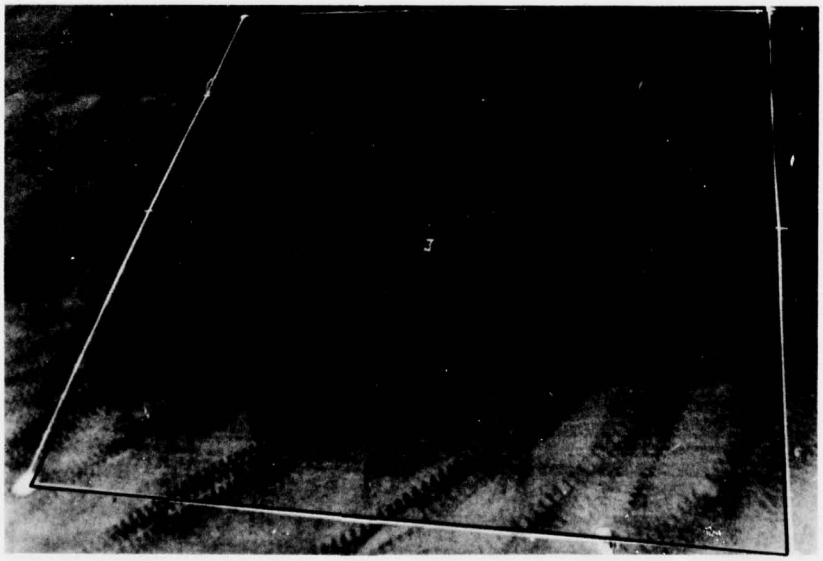


a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 80. Fort Stewart--test square in north end end of Sahuaro rubber section

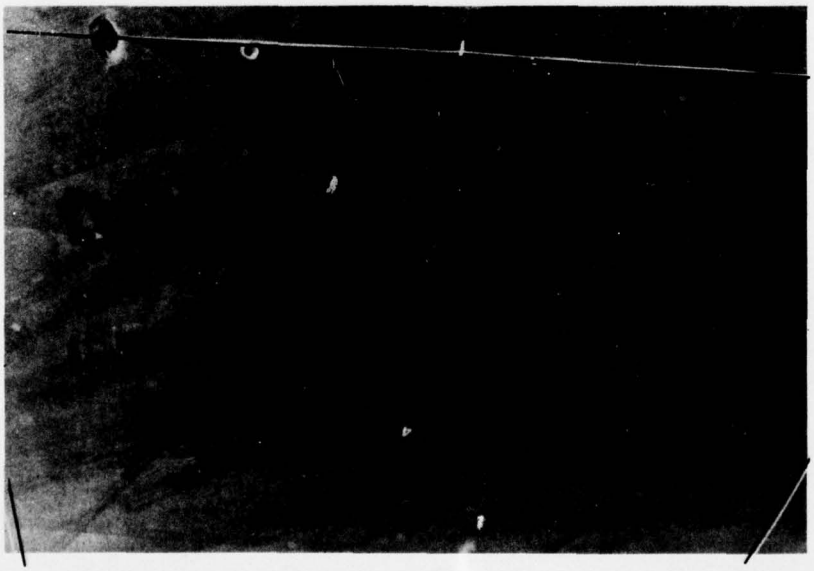
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

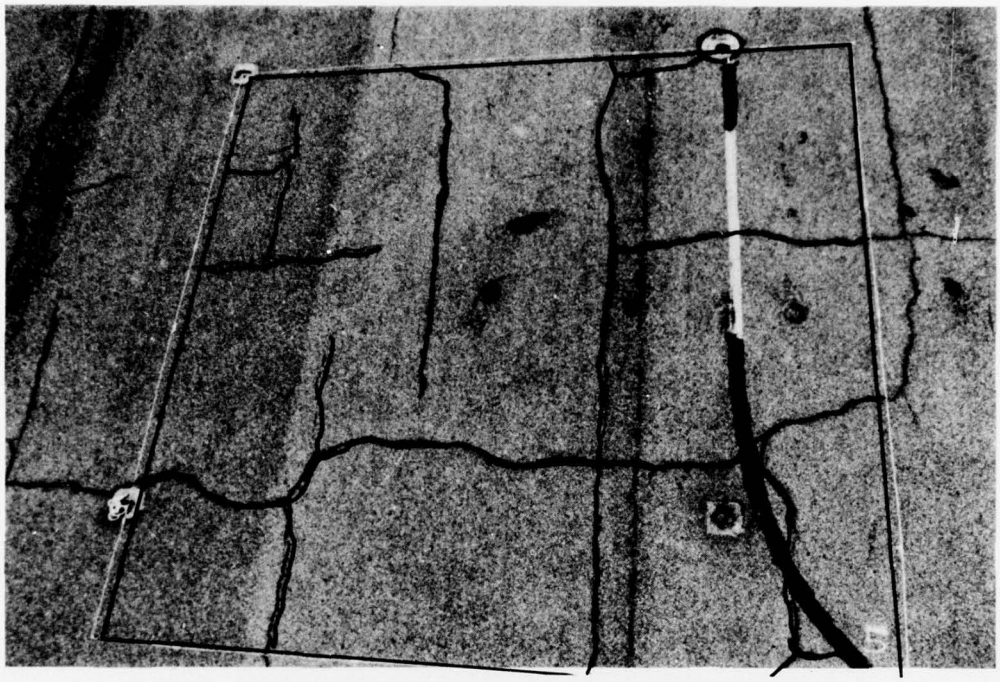
Photo 81. Fort Stewart--test square in south end of U. S. Rubber section

a. Condition of surface prior to overlay

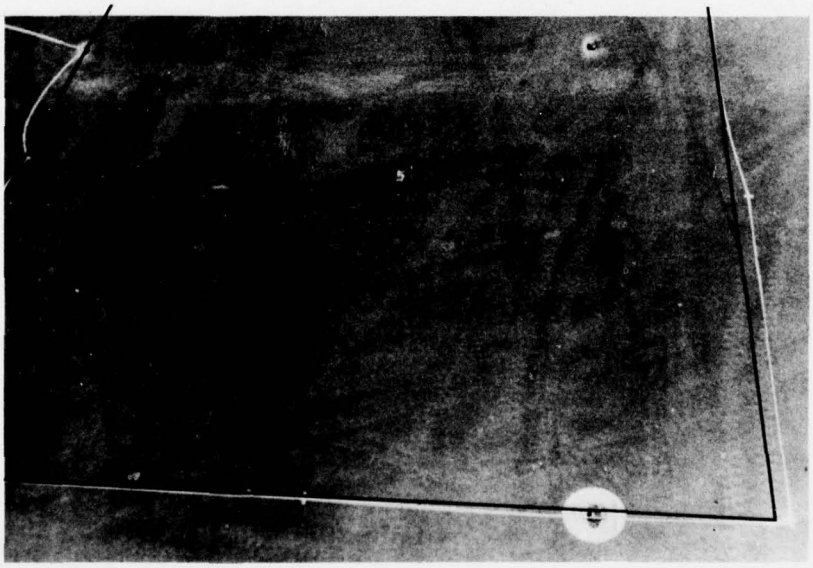


b. Condition of surface 6 months after overlay

Photo 82. Fort Stewart--test square in north end of U. S. Rubber section

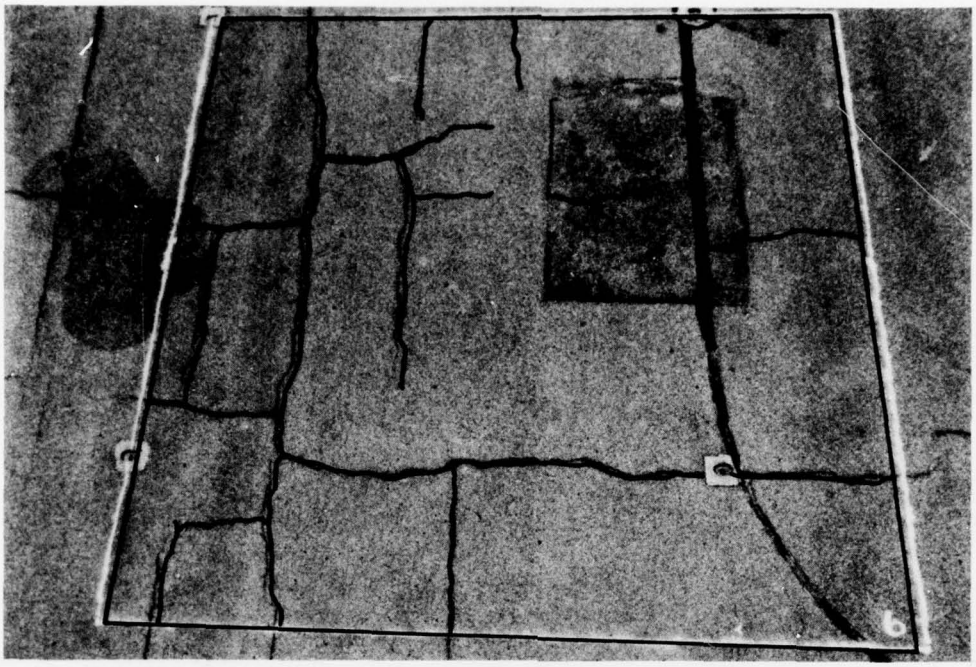


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

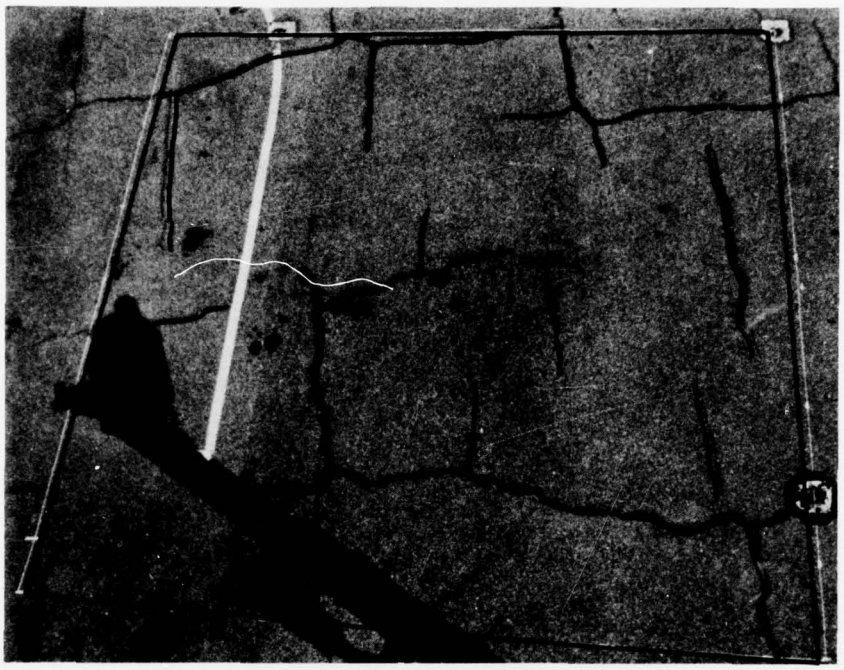
Photo 83. Fort Stewart--test square in north end of Bidim C-22 fabric section



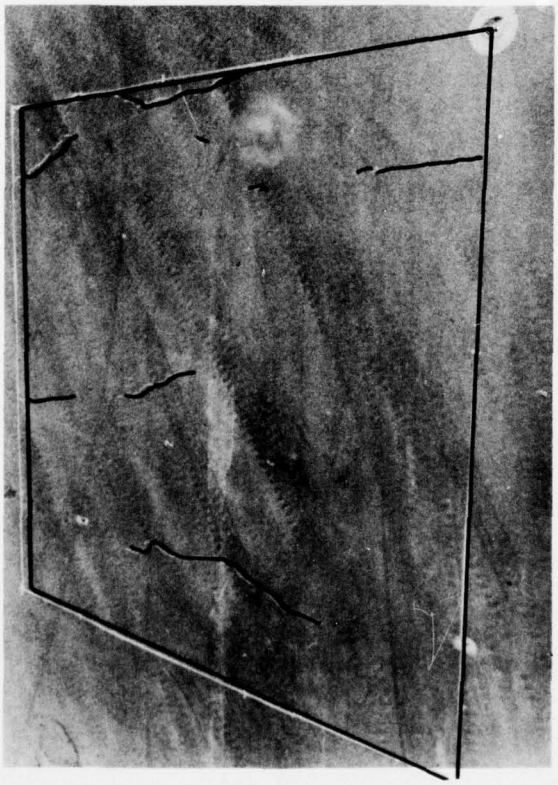
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 84. Fort Stewart--test square in south end of Bidim C-22 fabric section

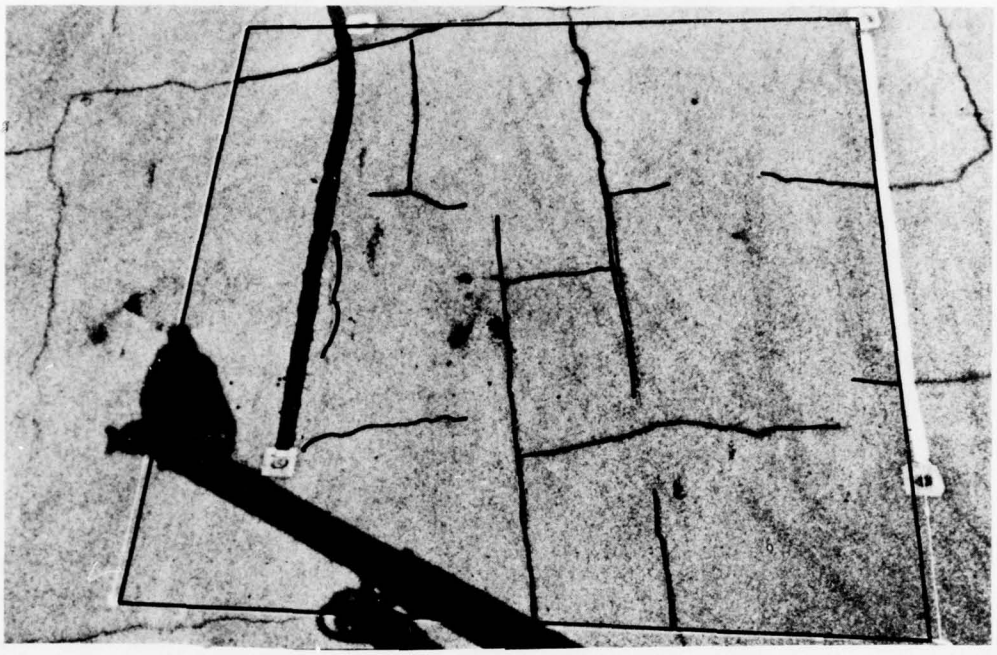


a. Condition of surface prior to overlay

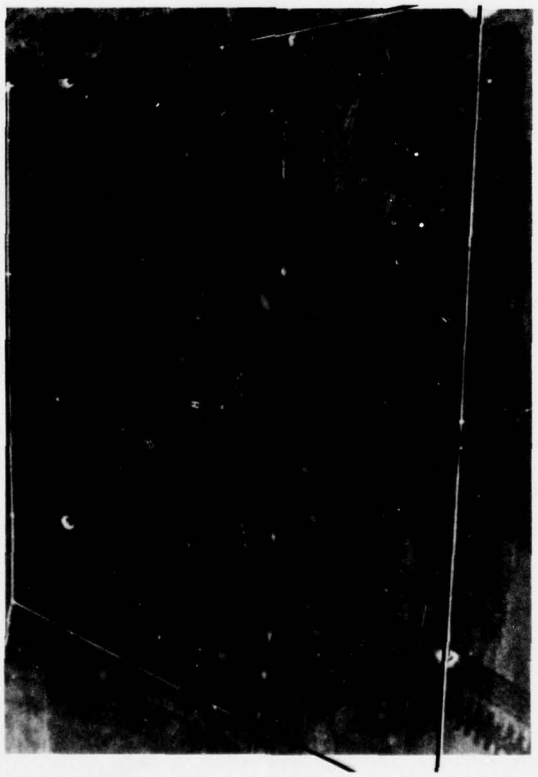


b. Condition of surface 6 months after overlay

Photo 85. Fort Stewart--test square in south end of Mirafi 140 fabric section

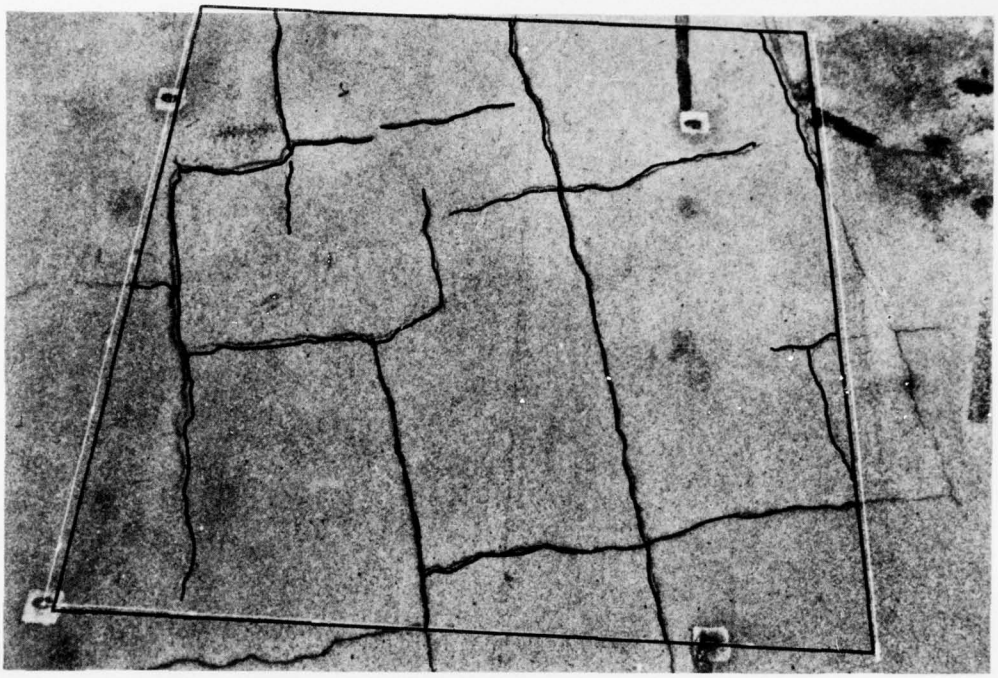


a. Condition of surface prior to overlay

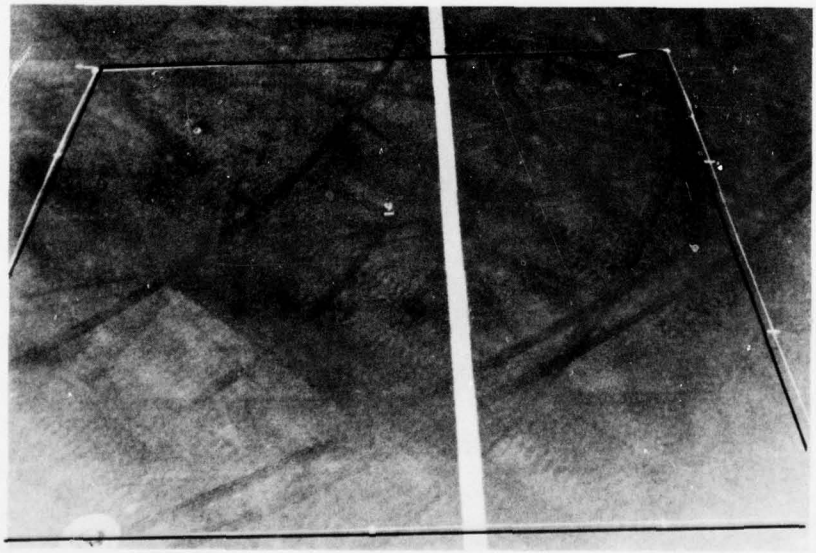


b. Condition of surface 6 months after overlay

Photo 86. Fort Stewart--test square in north end of Mirafi 140 fabric section



a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 87. Fort Stewart--test square in south end of control section

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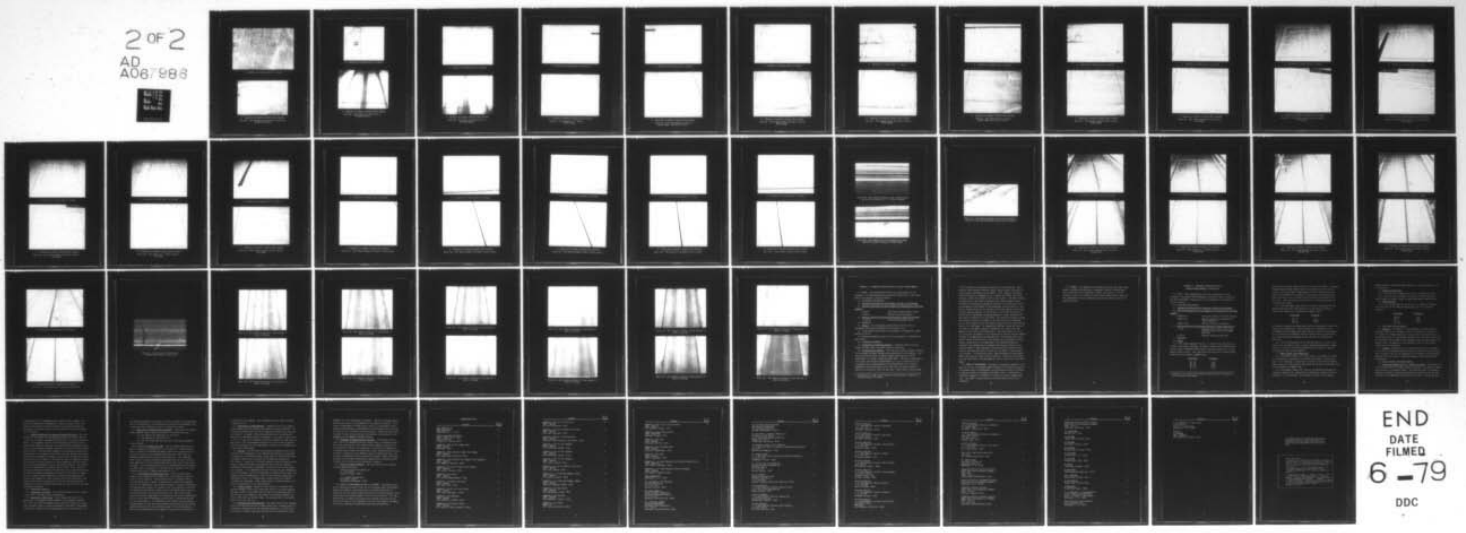

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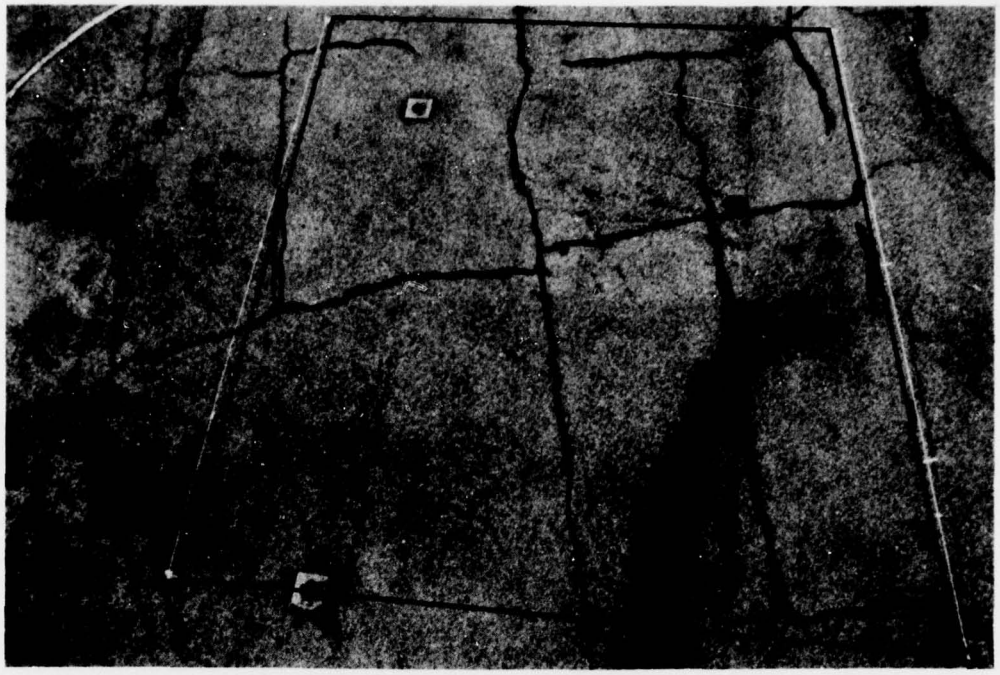
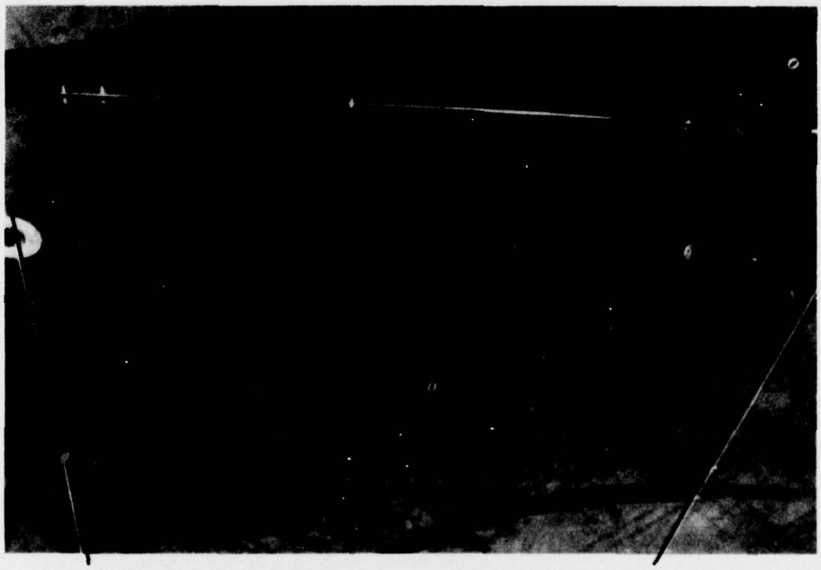
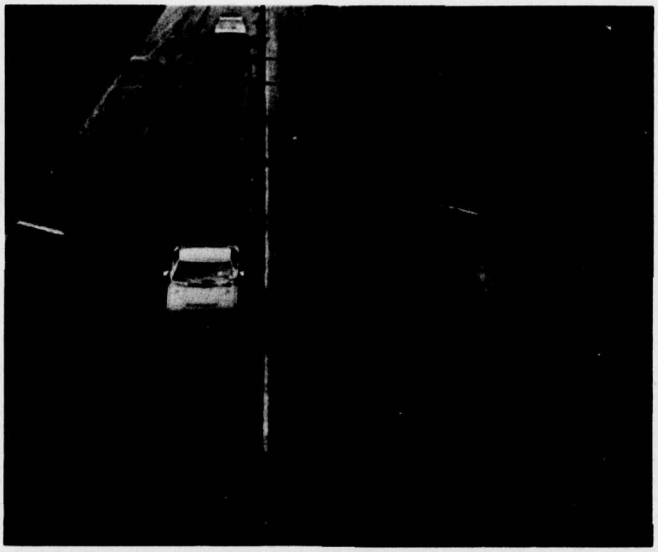


a. Condition of surface prior to overlay

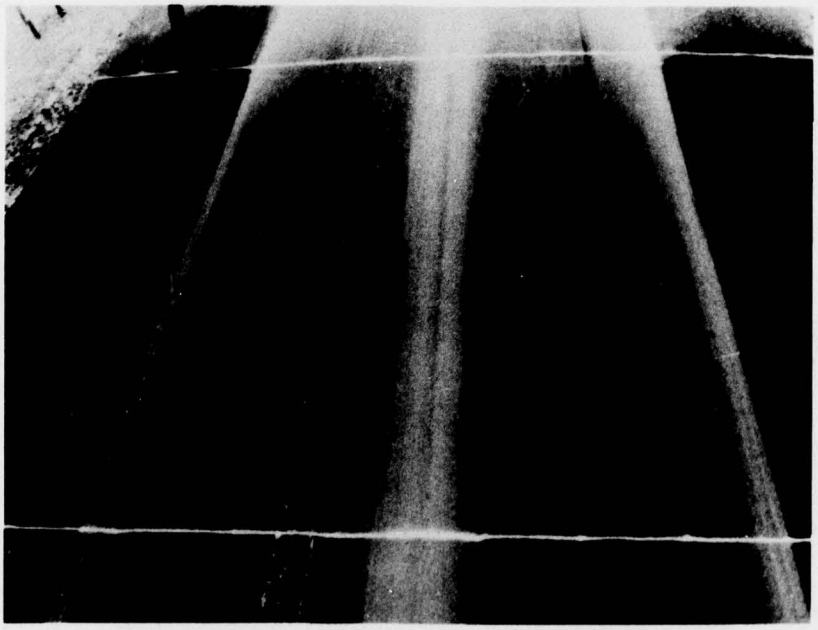


b. Condition of surface 6 months after overlay

Photo 88. Fort Stewart--test section in north end of control section

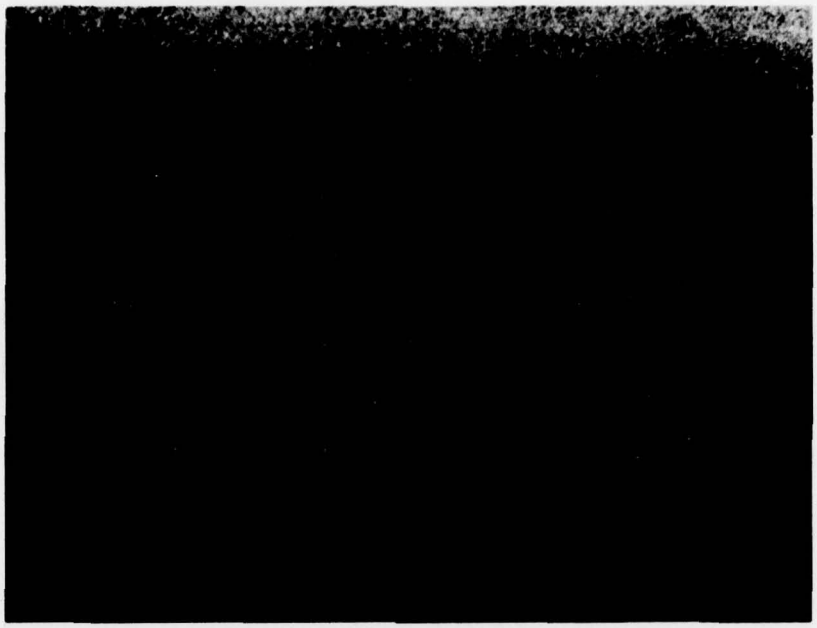


a. Condition of surface prior to overlay

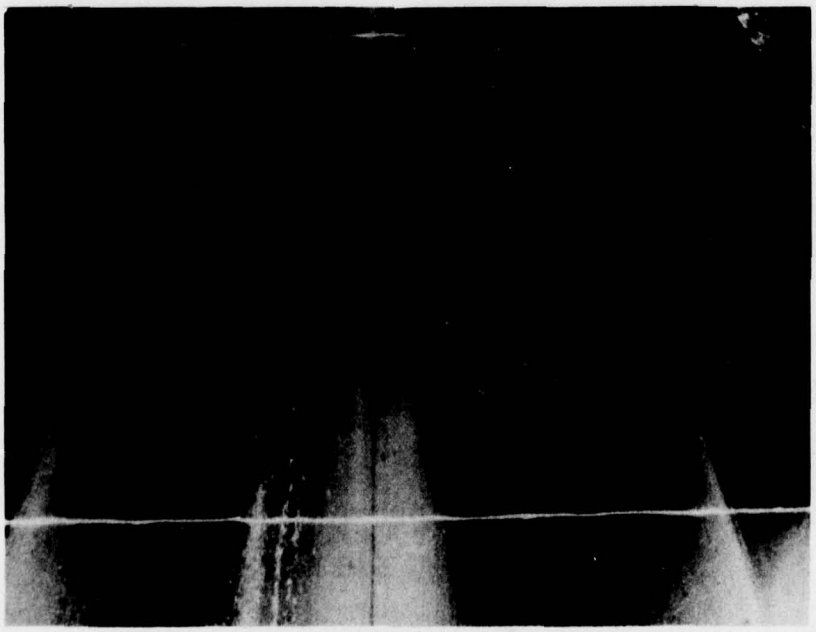


b. Condition of surface 6 months after overlay

Photo 89. Fort Polk--test section No. 1, Louisiana Avenue

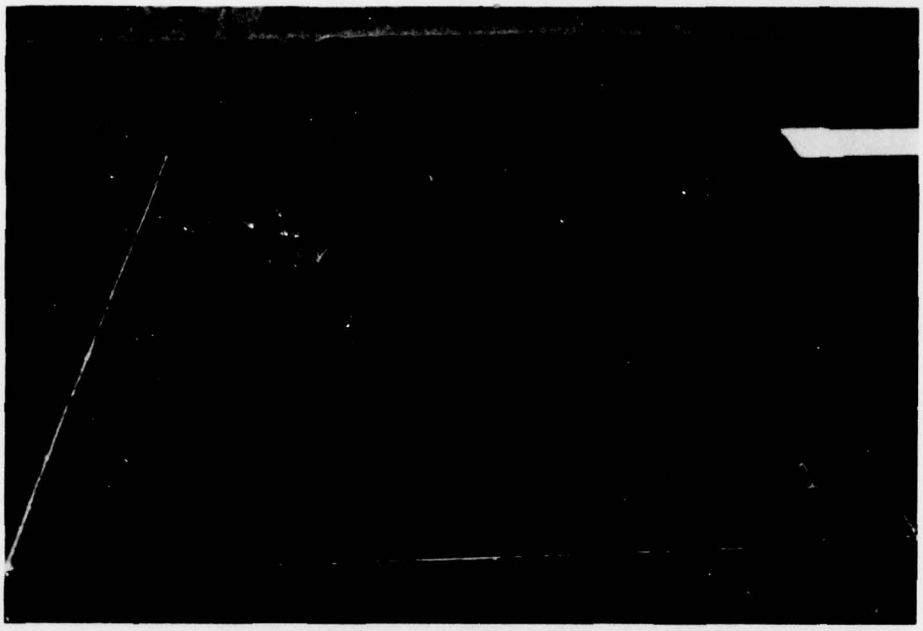


a. Condition of surface prior to overlay

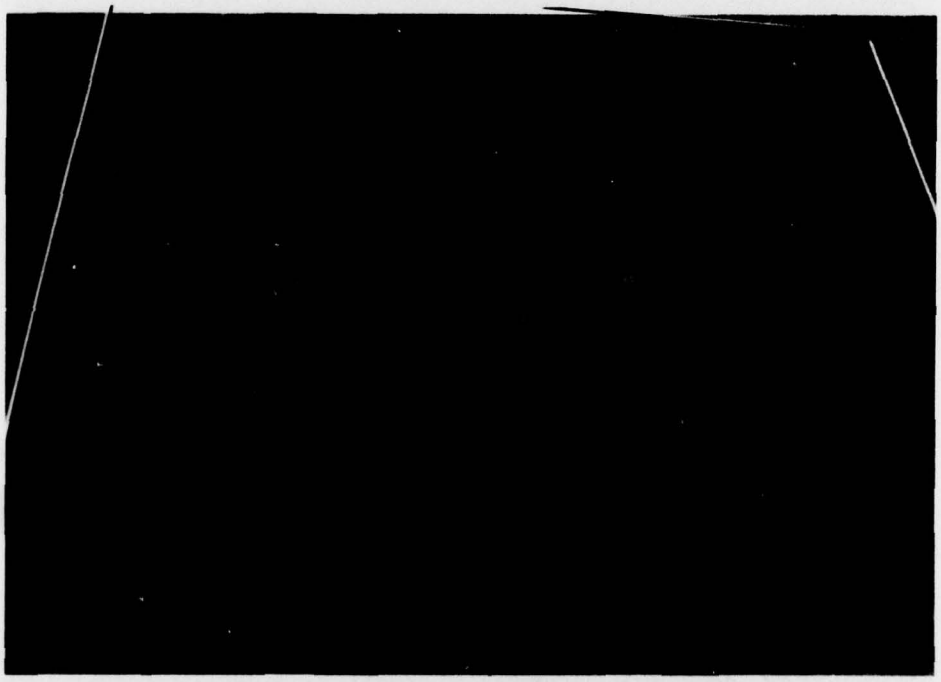


b. Condition of surface 6 months after overlay

Photo 90. Fort Polk--test section No. 2, Louisiana Avenue

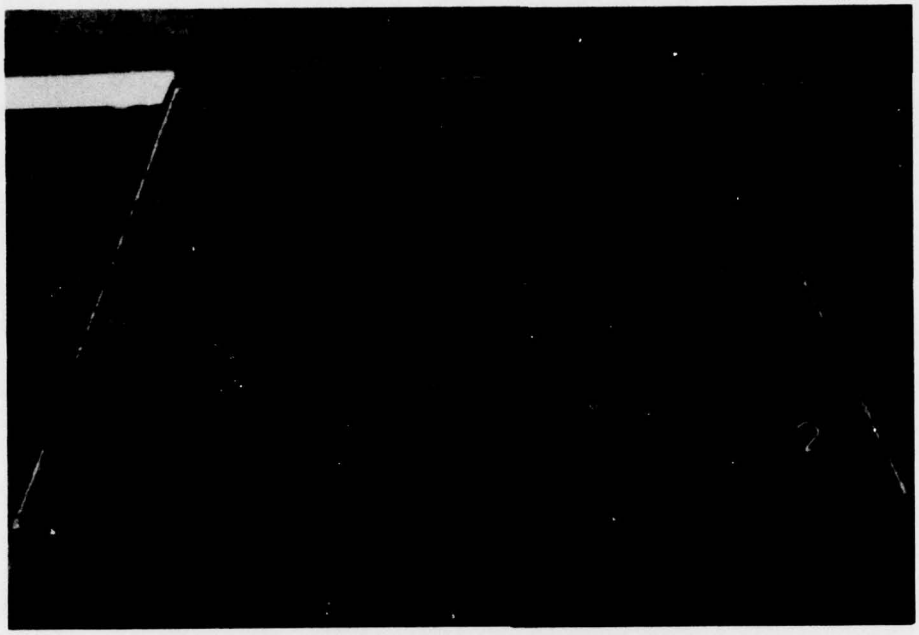


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

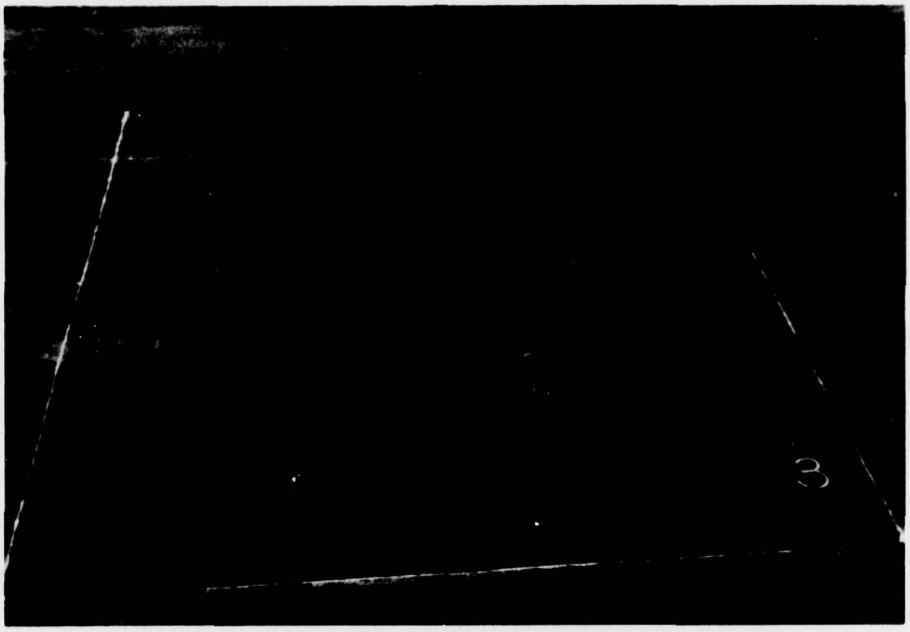
Photo 91. Fort Devens--U. S. Rubber,
NW-SE runway



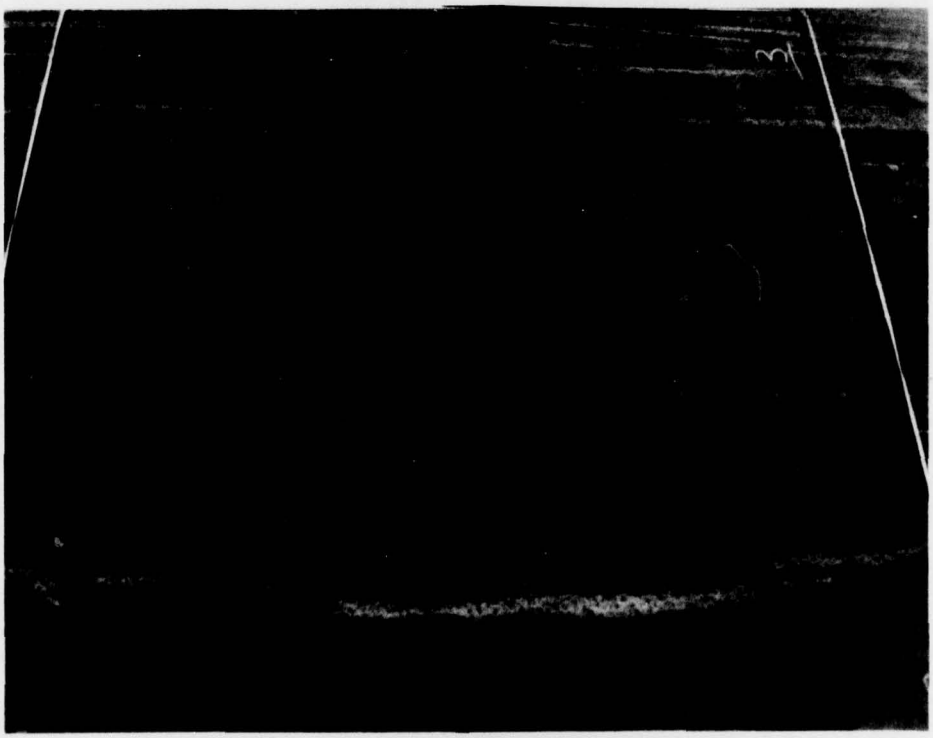
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 92. Fort Devens--control section,
NW-SE runway, sta 19+50 to 21+50

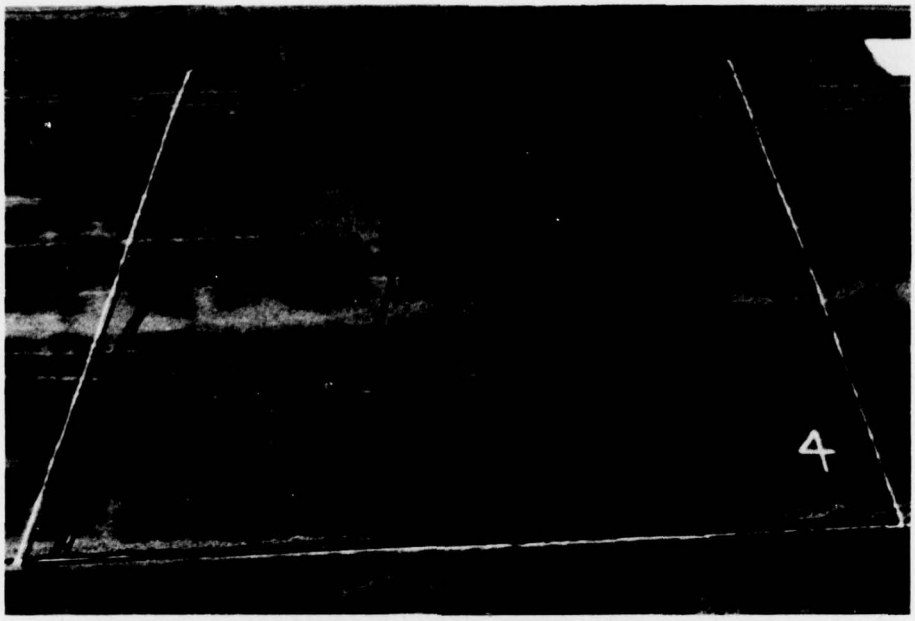


a. Condition of surface prior to overlay

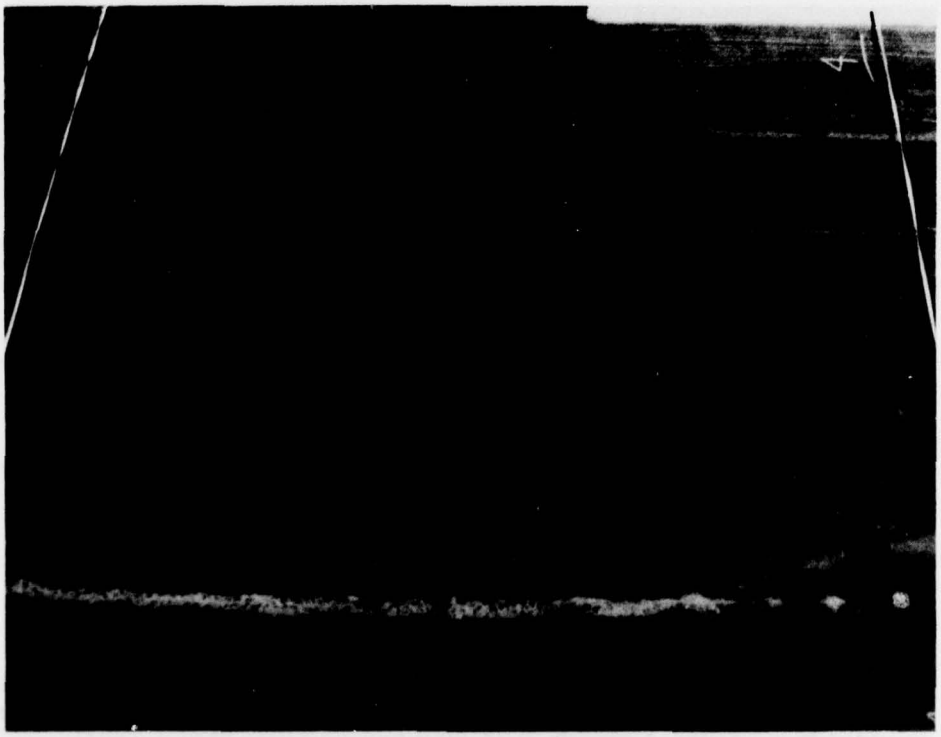


b. Condition of surface 6 months after overlay

Photo 93. Fort Devens--Bidim C-22 fabric section, NW-SE runway

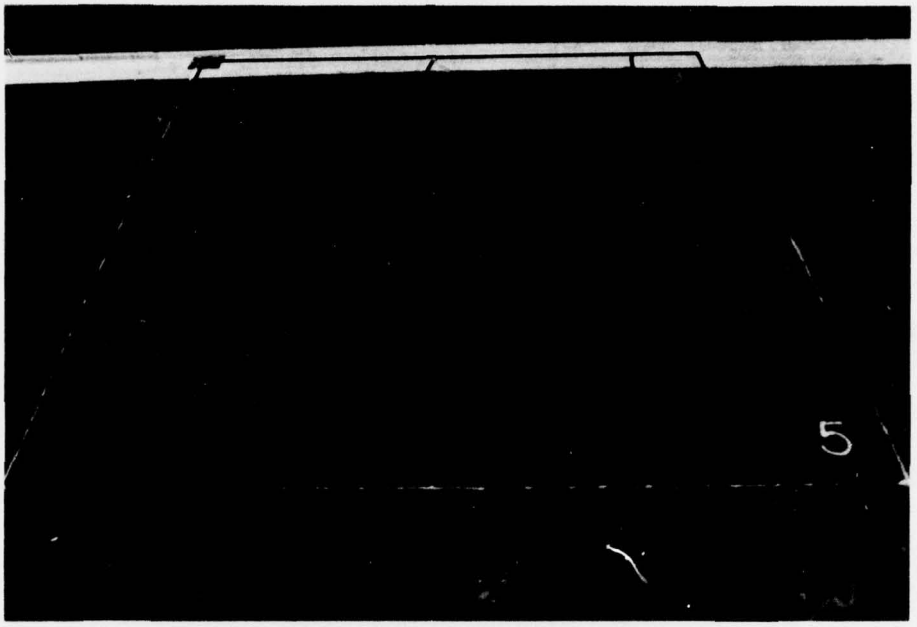


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

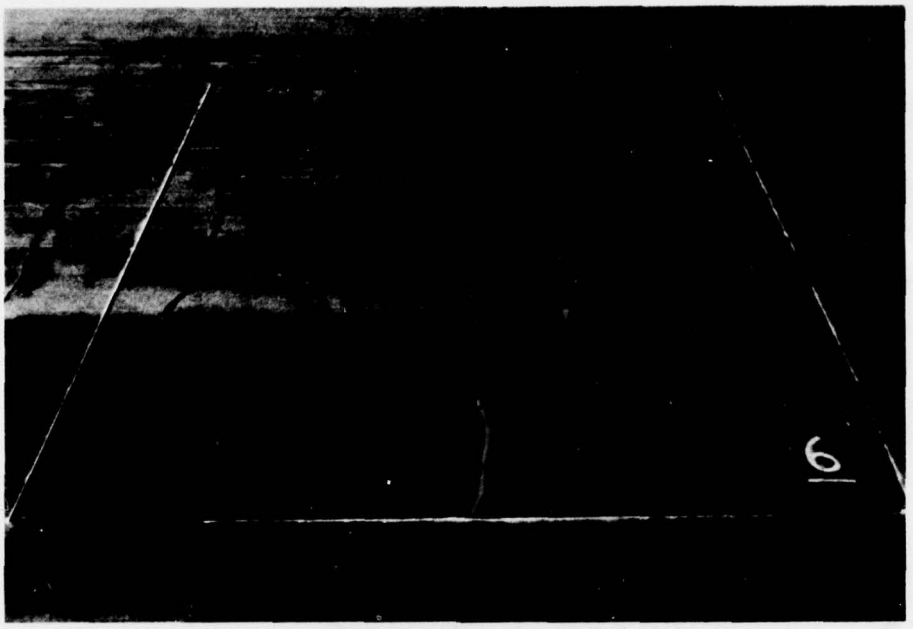
Photo 94. Fort Devens--Mirafi 140 fabric section, NW-SE runway



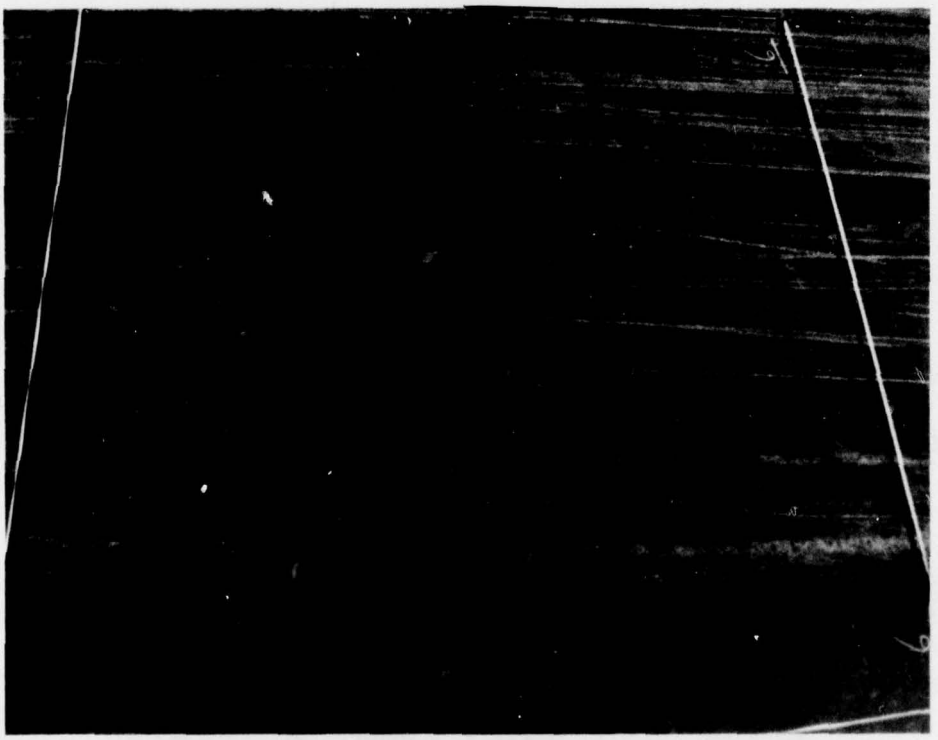
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 95. Fort Devens--control section, NW-SE runway, sta 25+50 to 27+50

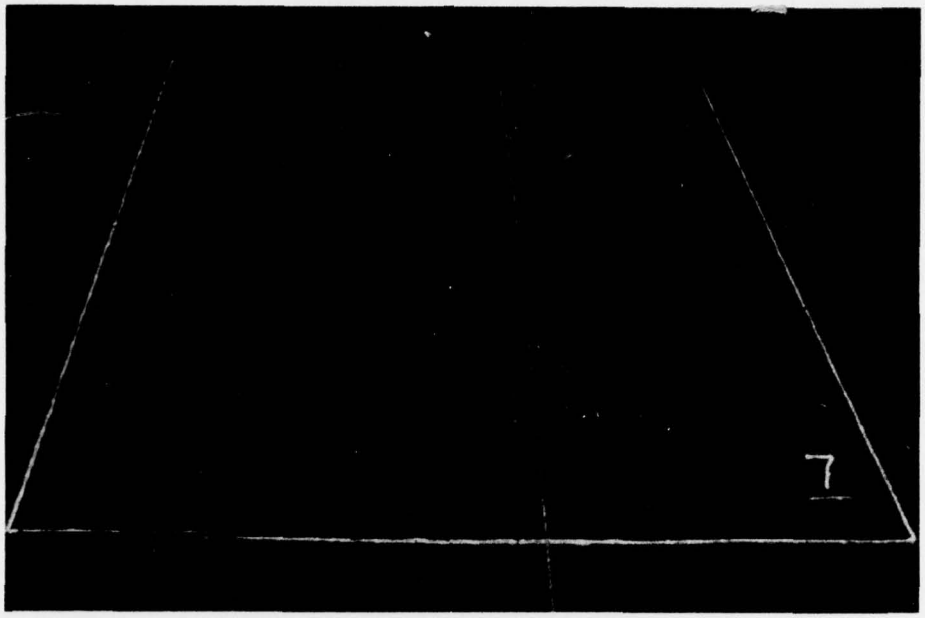


a. Condition of surface prior to overlay

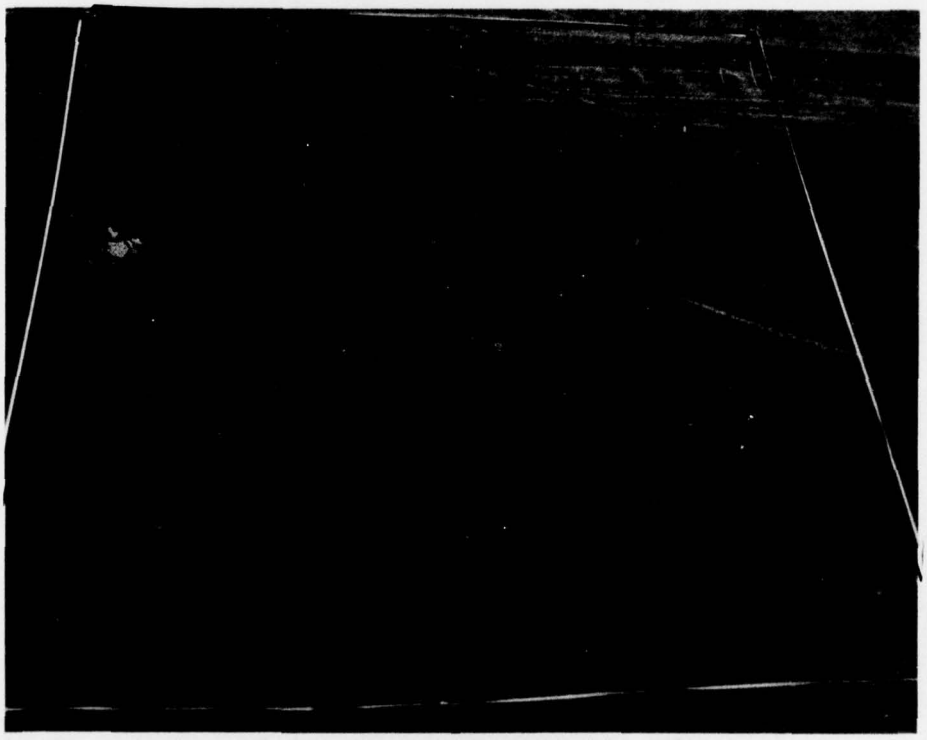


b. Condition of surface 6 months after overlay

Photo 96. Fort Devens--Sahuaro rubber section, NW-SE runway

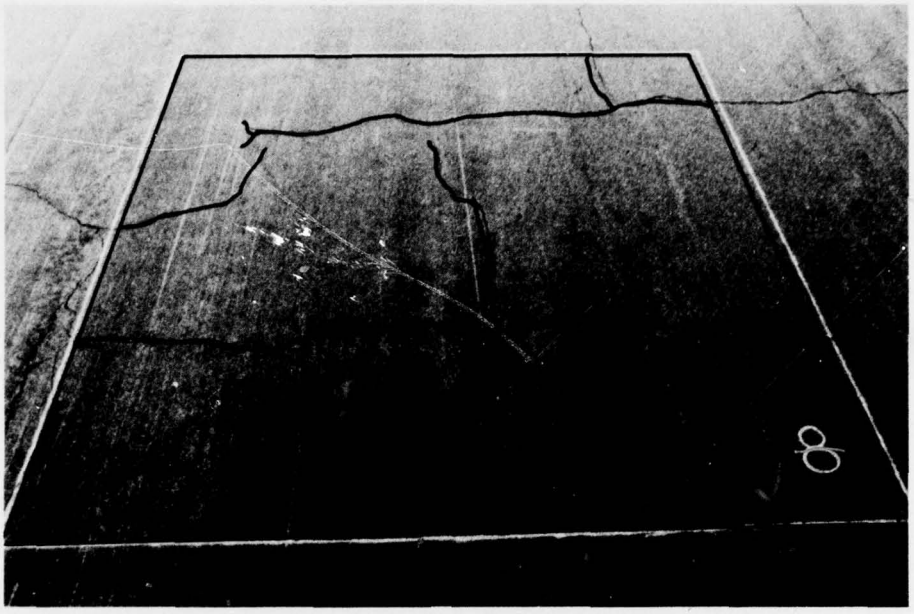


a. Condition of surface prior to overlay

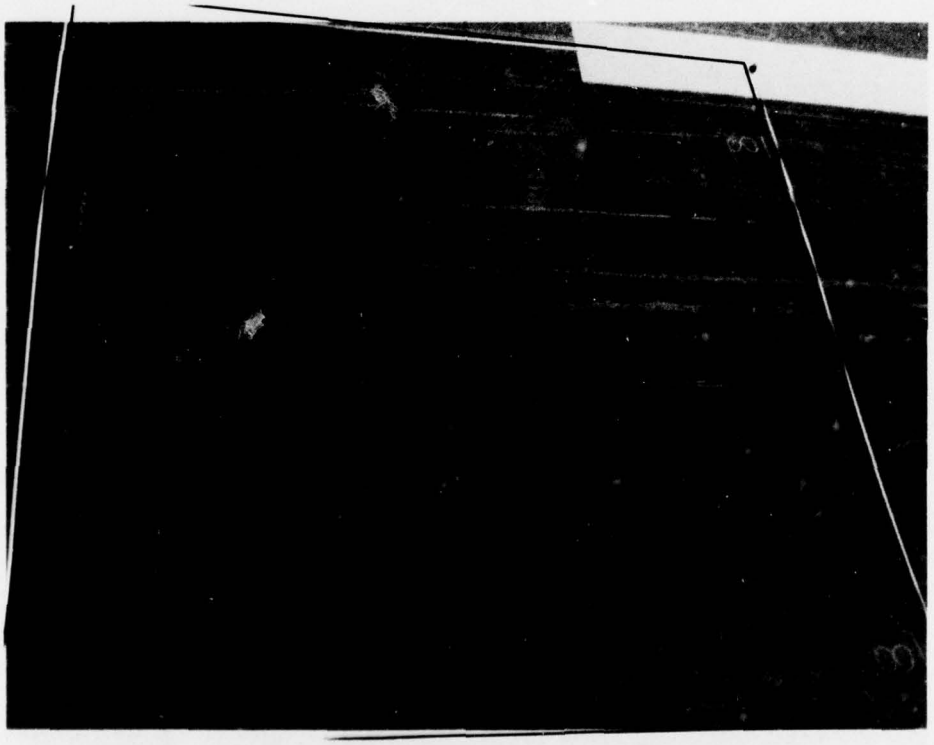


b. Condition of surface 6 months after overlay

Photo 97. Fort Devens--Sahuaro rubber section, N-S runway

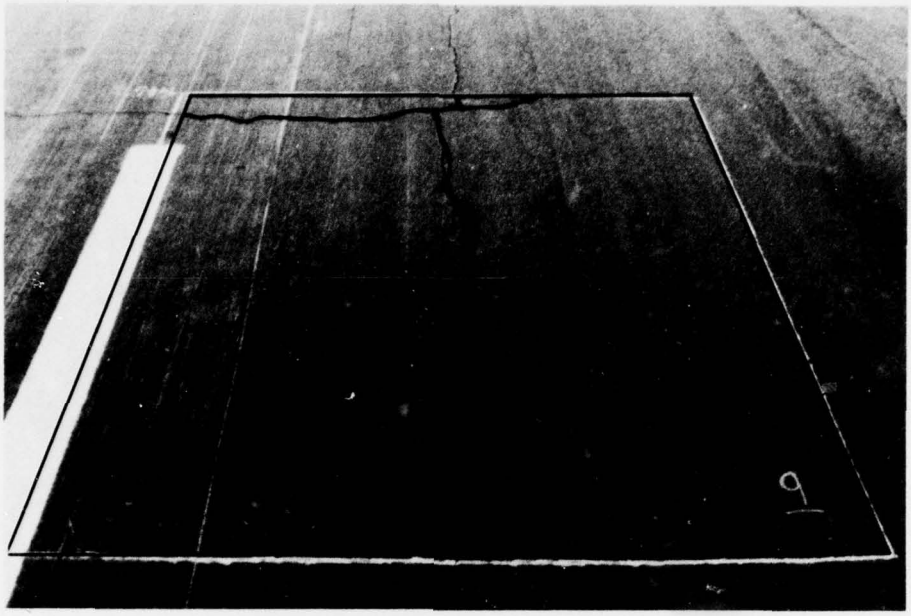


a. Condition of surface prior to overlay

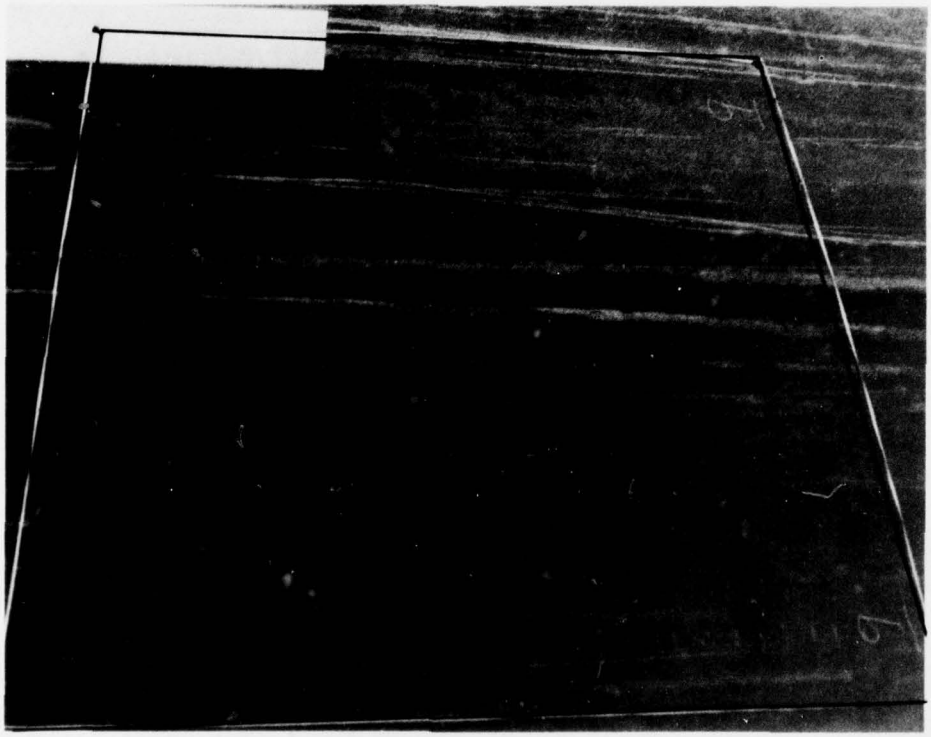


b. Condition of surface 6 months after overlay

Photo 98. Fort Devens--control section (south), N-S runway

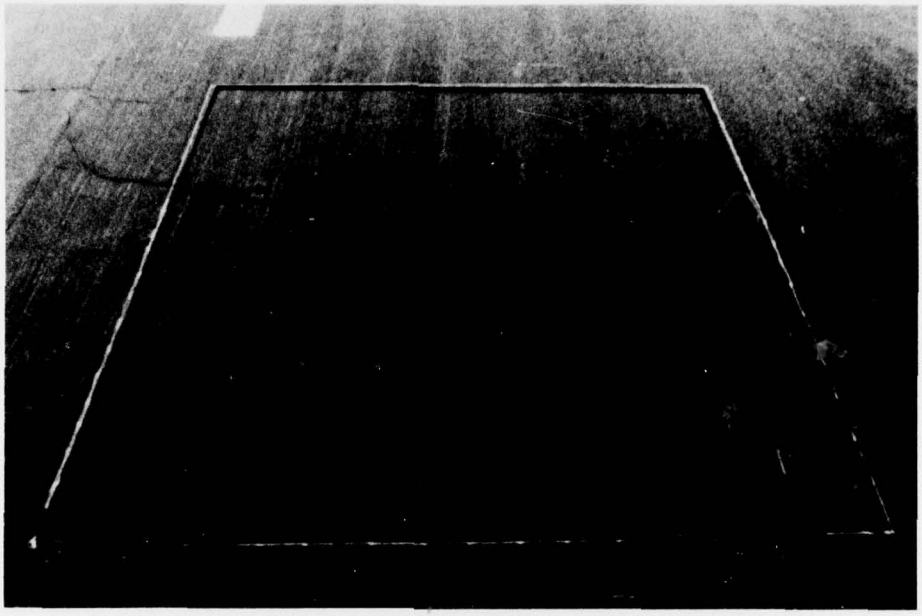


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

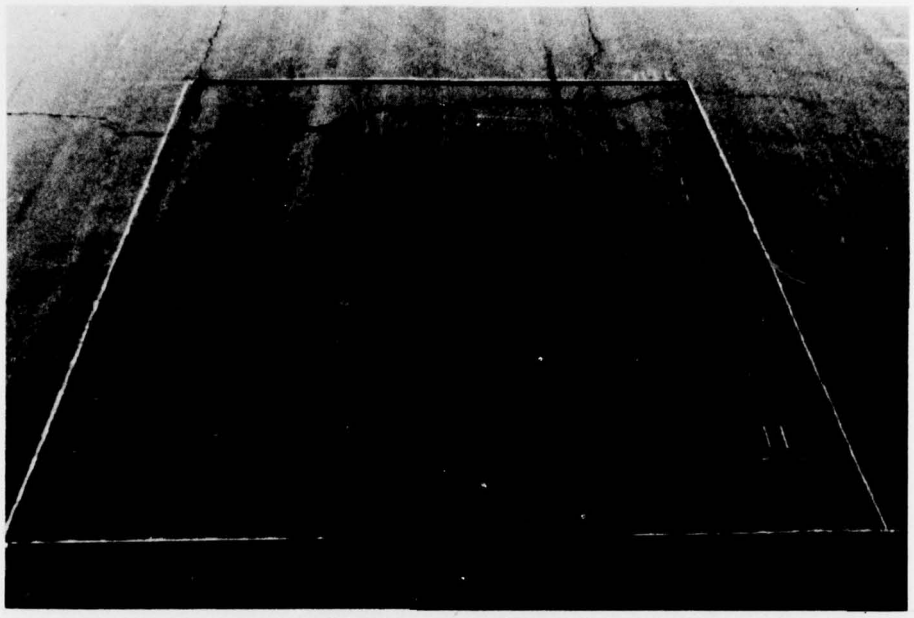
Photo 99. Fort Devens--Bidim C-22 fabric section, N-S runway



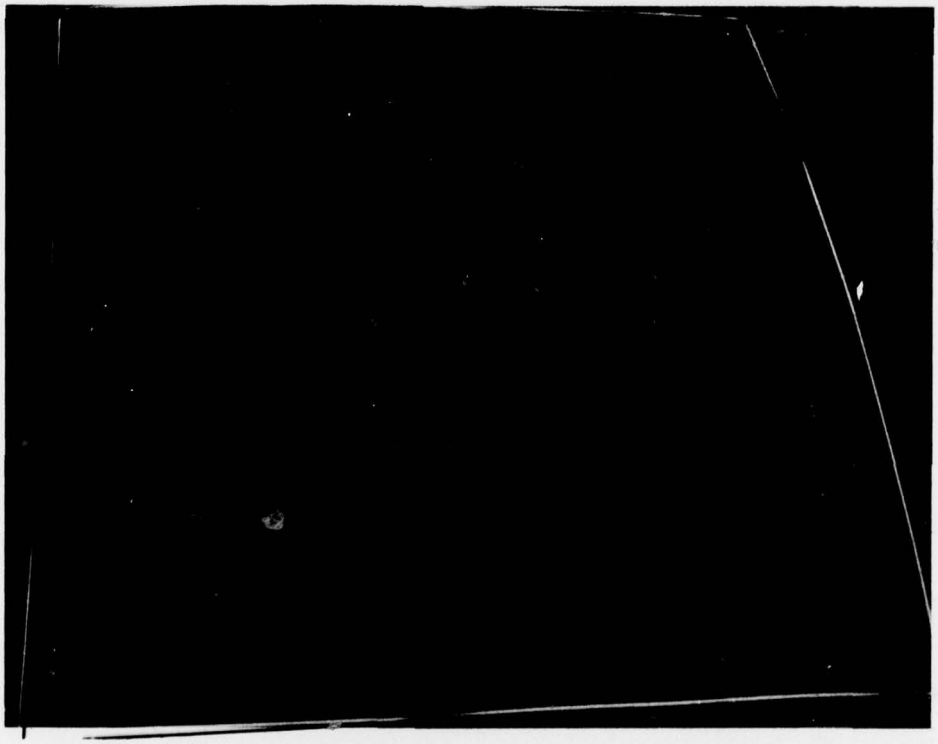
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 100. Fort Devens--Mirafi 140 fabric section, N-S runway

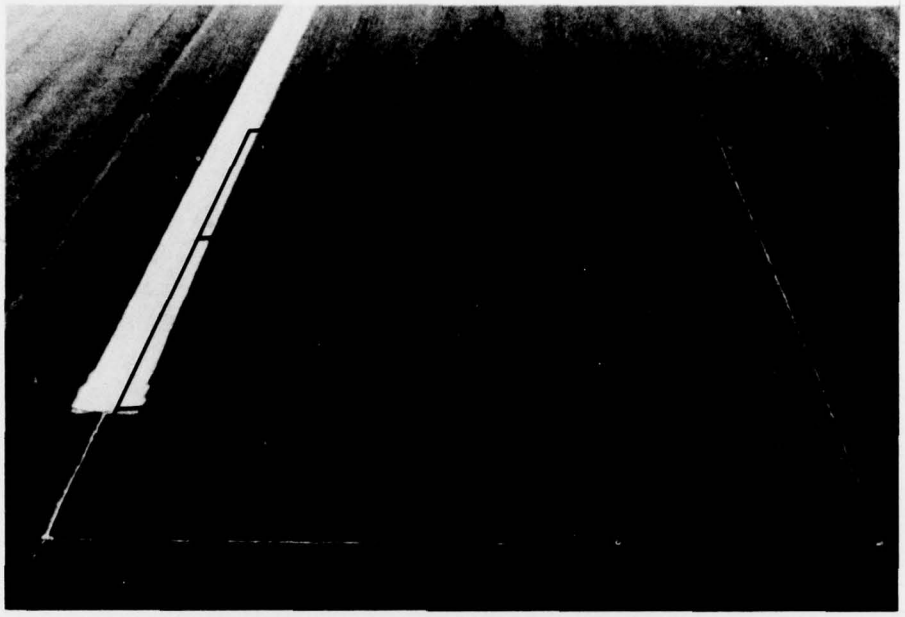


a. Condition of surface prior to overlay

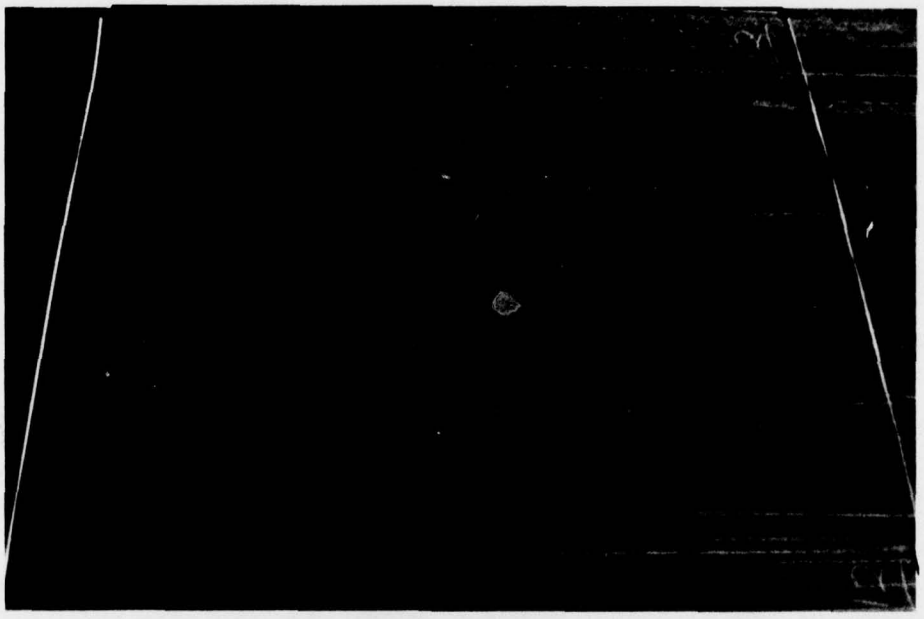


b. Condition of surface 6 months after overlay

Photo 101. Fort Devens--U. S. Rubber section
N-S runway

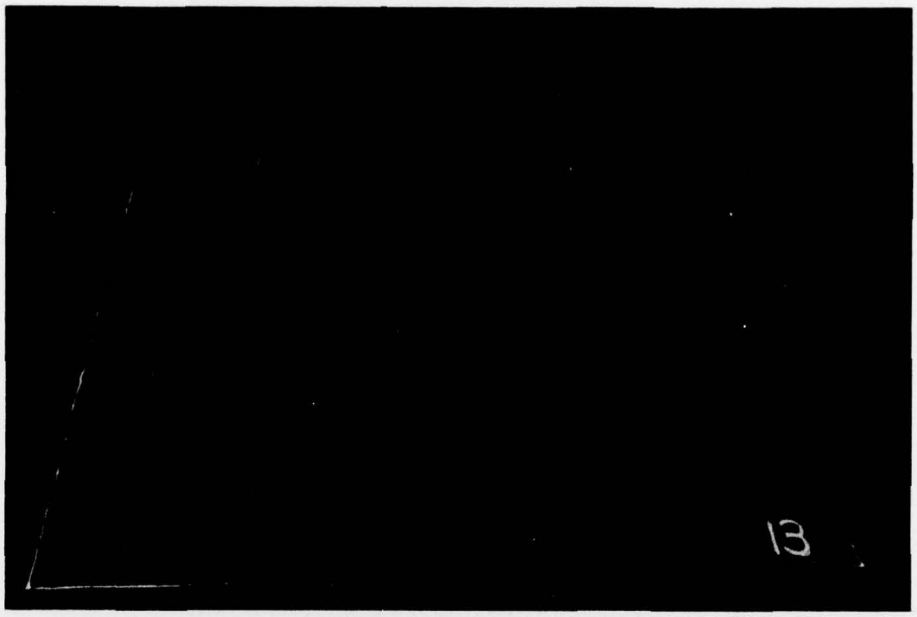


a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

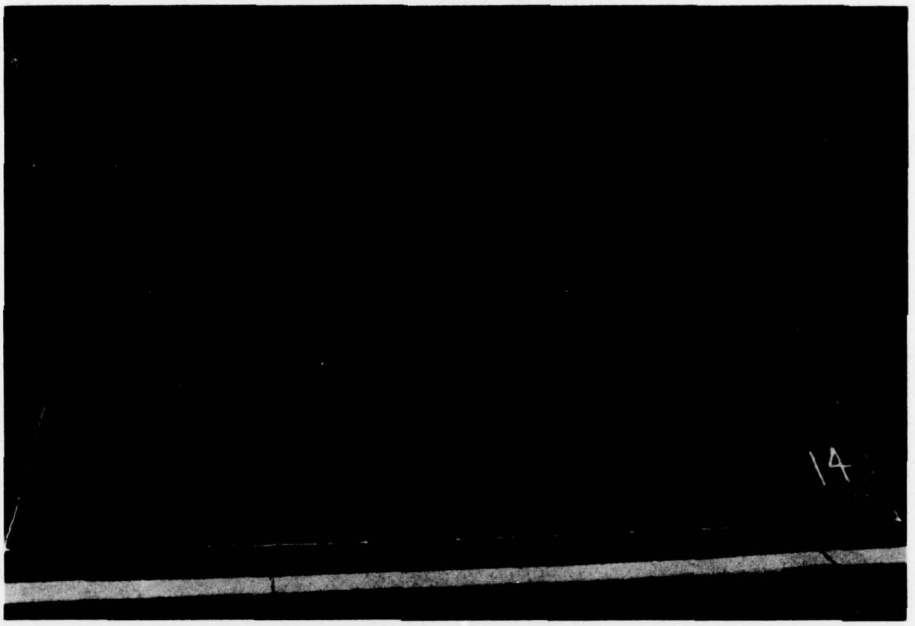
Photo 102. Fort Devens--control section (north), N-S runway



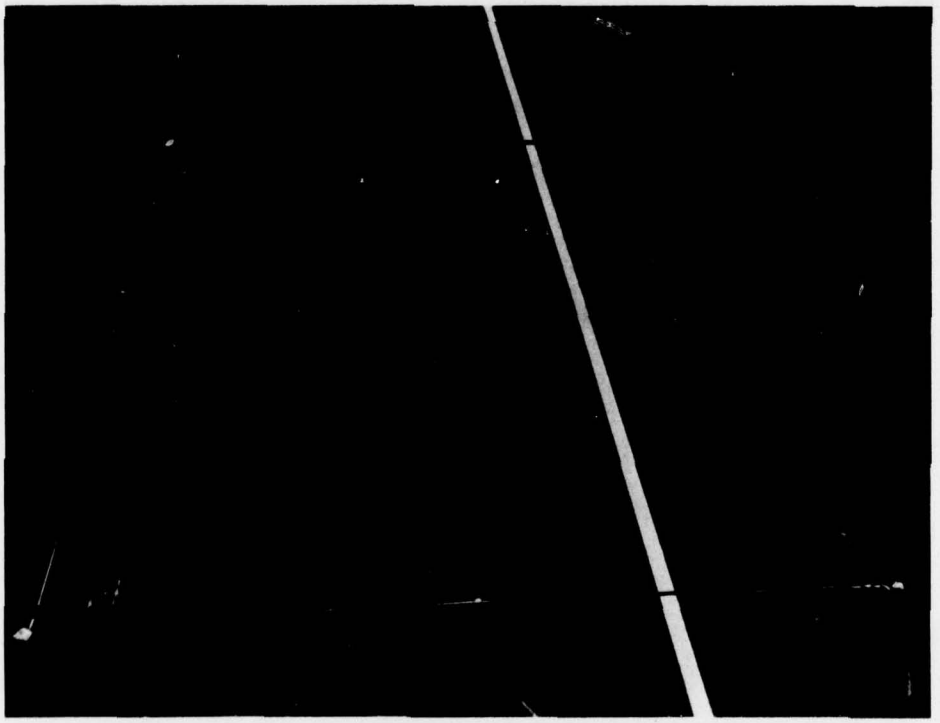
a. Condition of surface prior to overlay

b. Condition of surface 6 months after overlay

Photo 103. Fort Devens--Bidim C-22 fabric section, apron

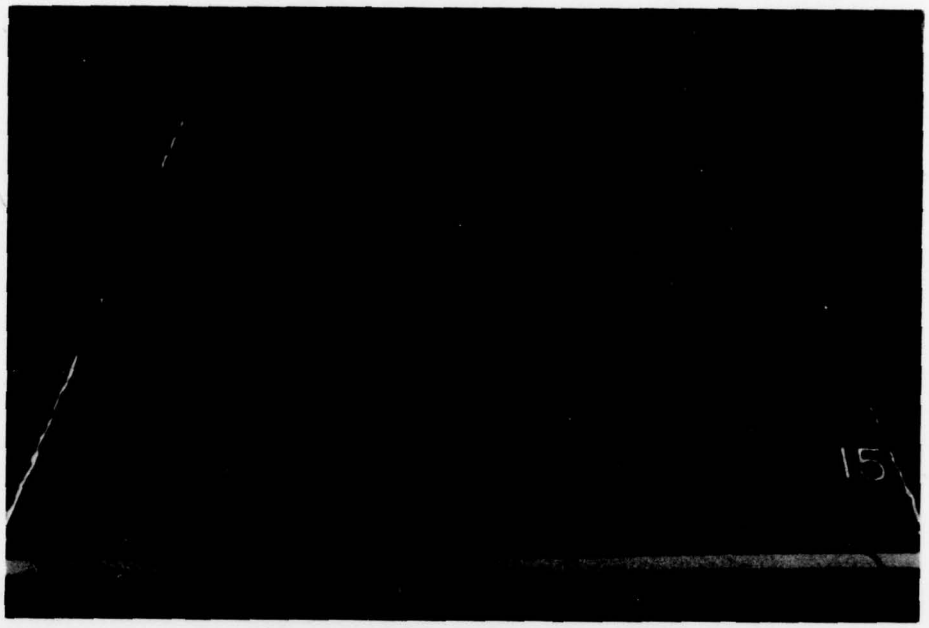


a. Condition of surface prior to overlay

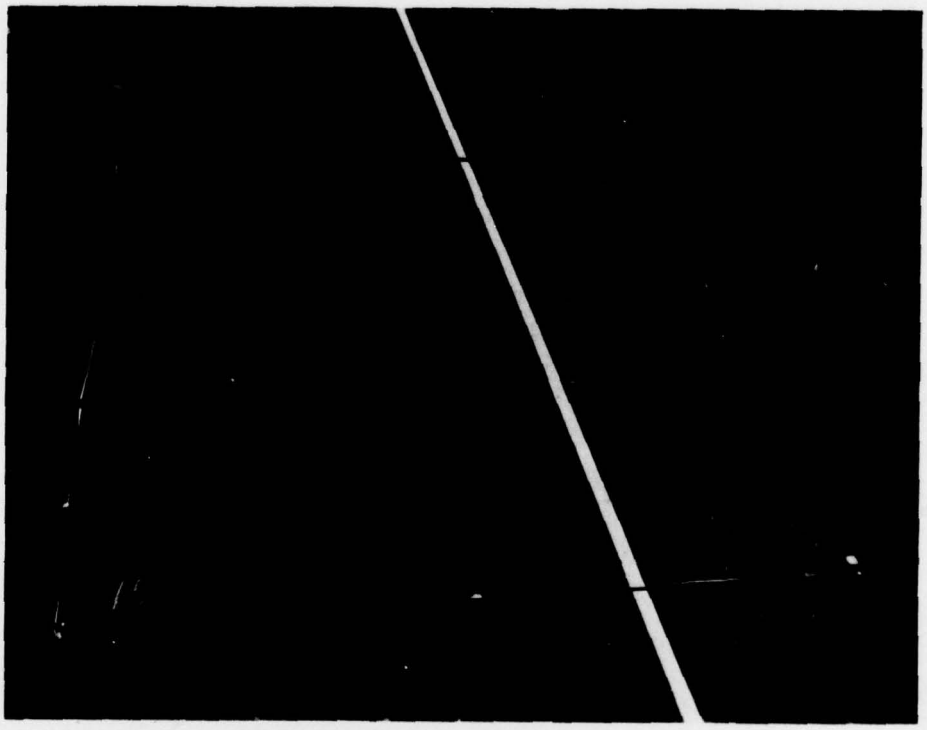


b. Condition of surface 6 months after overlay

Photo 104. Fort Devens--Mirafi 140 fabric section, apron

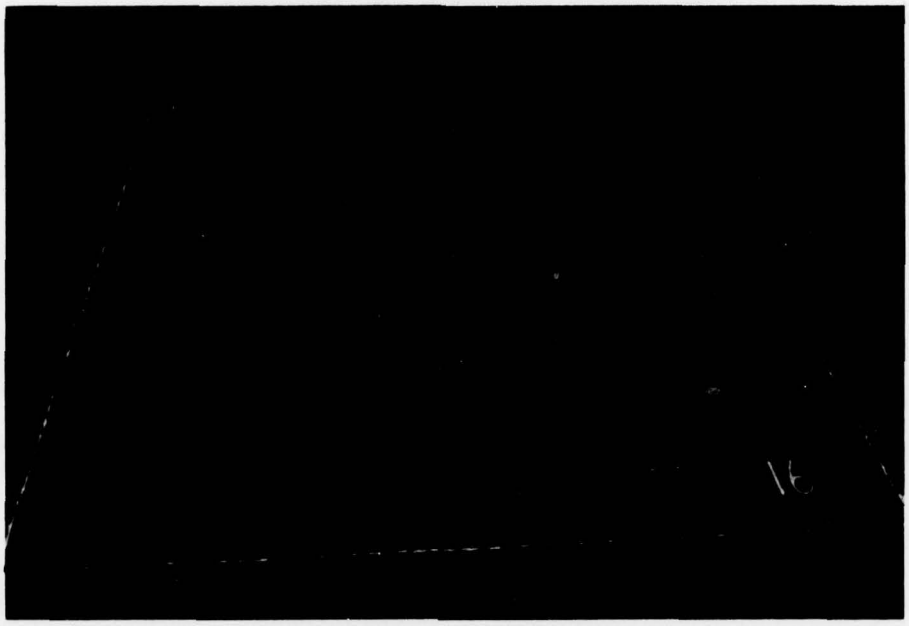


a. Condition of surface prior to overlay

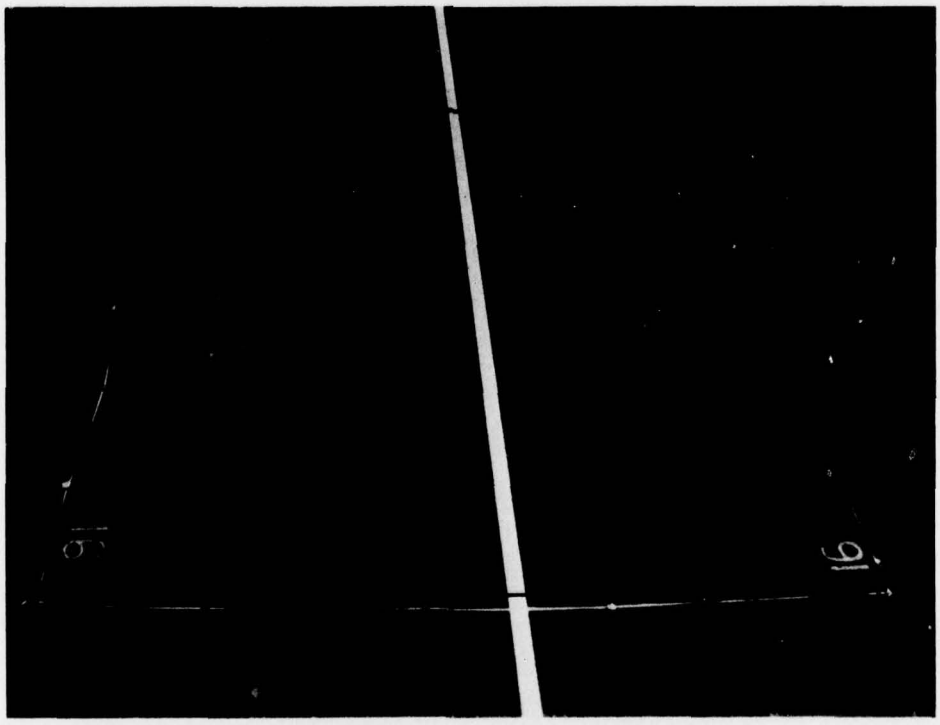


b. Condition of surface 6 months after overlay

Photo 105. Fort Devens--Sahuaro rubber section, apron

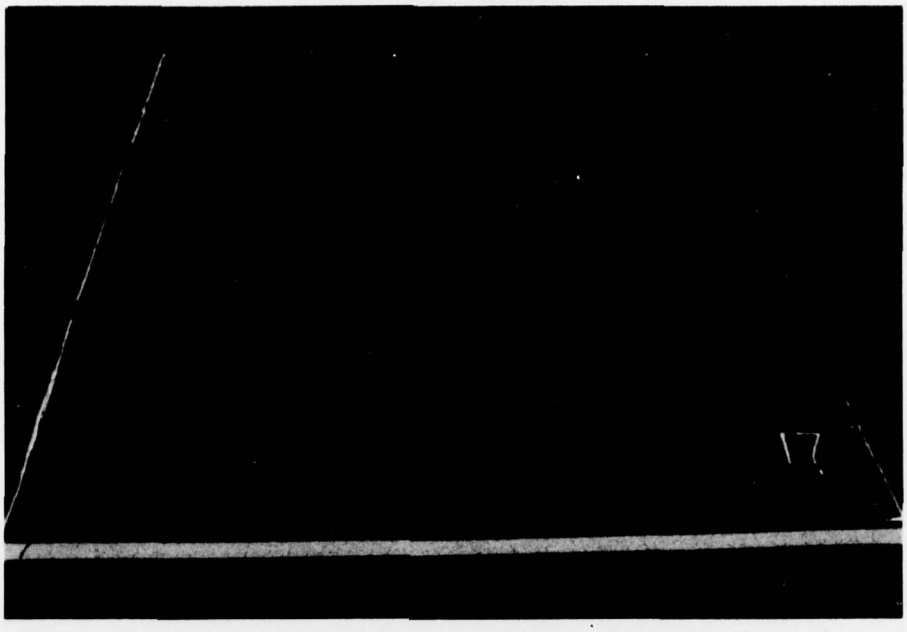


a. Condition of surface prior to overlay

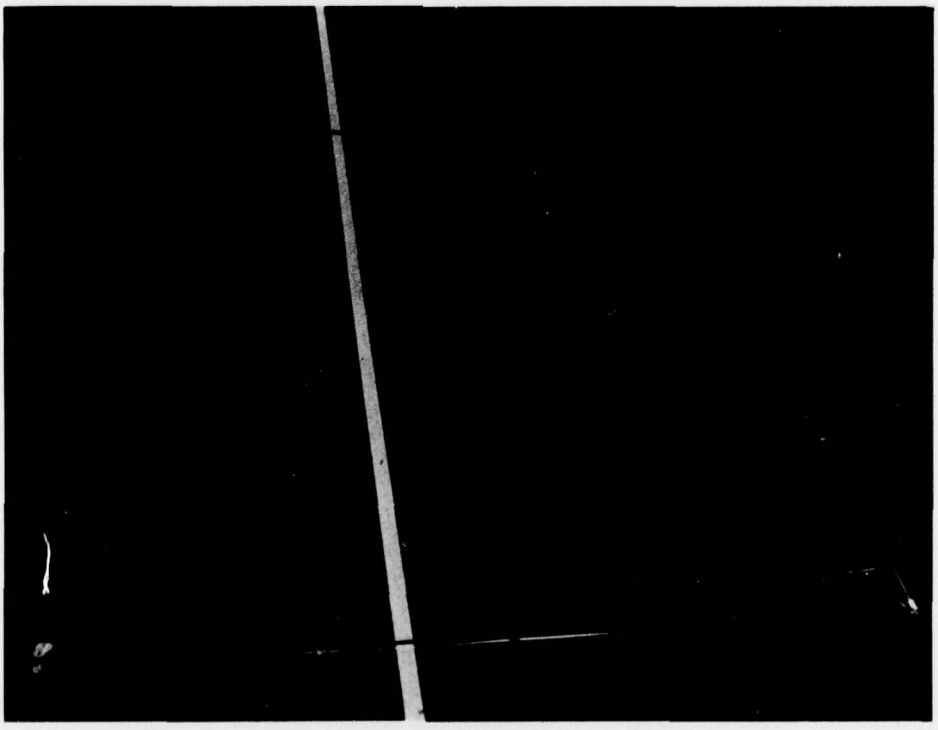


b. Condition of surface 6 months after overlay

Photo 106. Fort Devens--U. S. Rubber section, apron



a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 107. Fort Devens--control section, apron

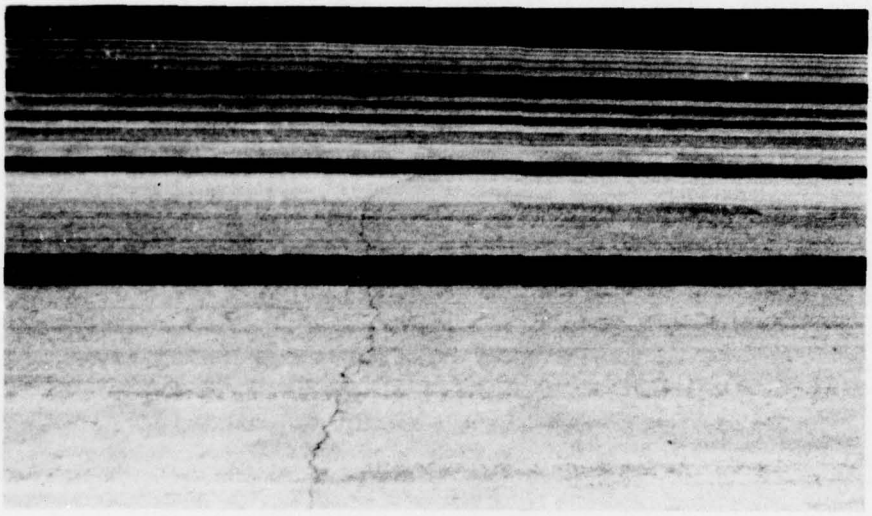


Photo 108. Fort Devens--reflected crack in NW-SE runway near NW end; interlayer of U. S. Rubber membrane

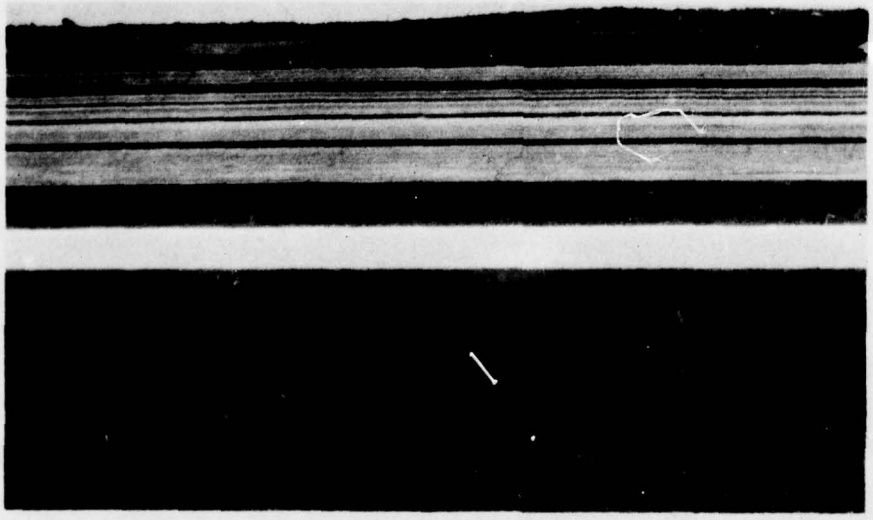


Photo 109. Fort Devens--one of five transverse cracks observed in control sections on NW-SE runway

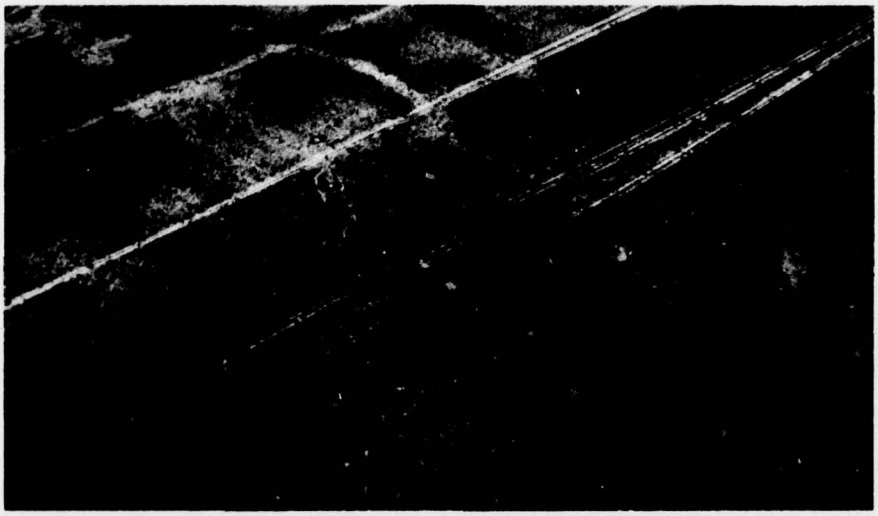
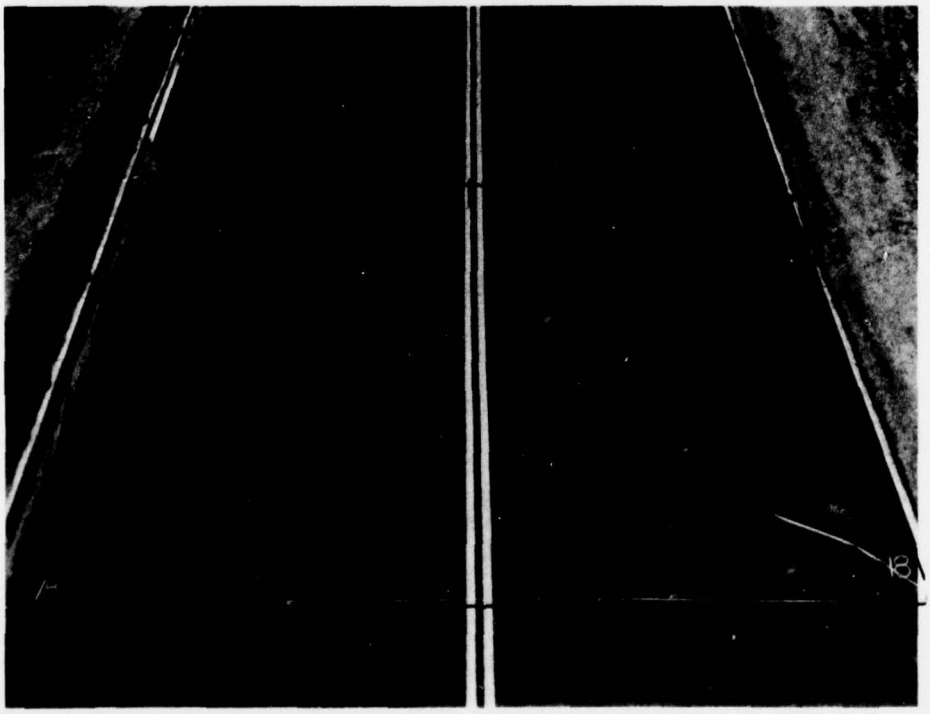


Photo 110. Fort Devens--gouged out area on N-S runway in Mirafi 140 test area from locked wheel turn of aircraft

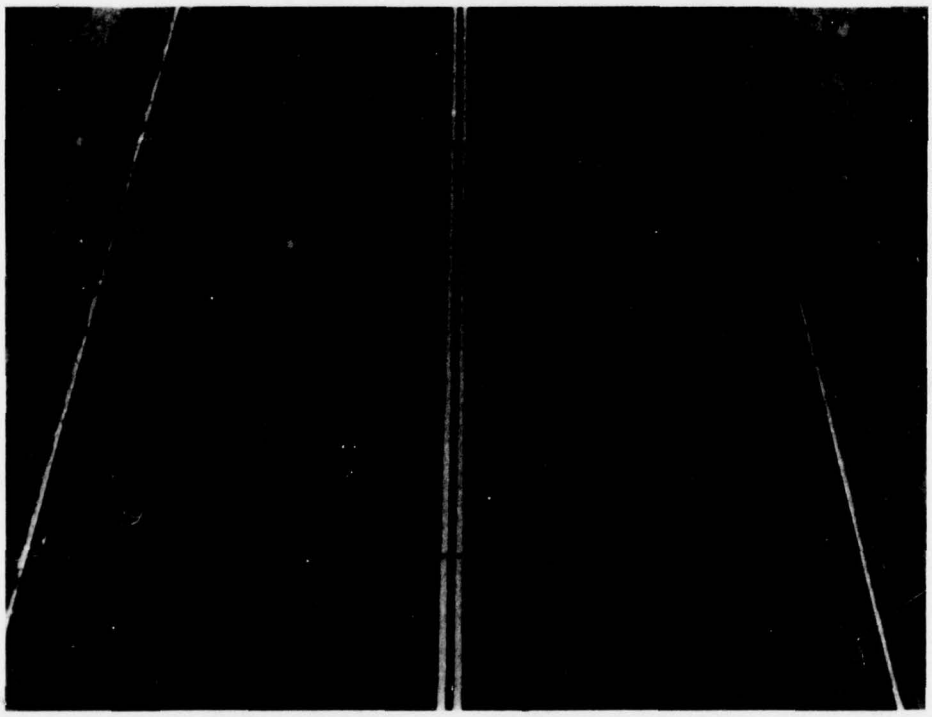
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 111. Fort Devens--Sahuaro rubber section, Barnum Road

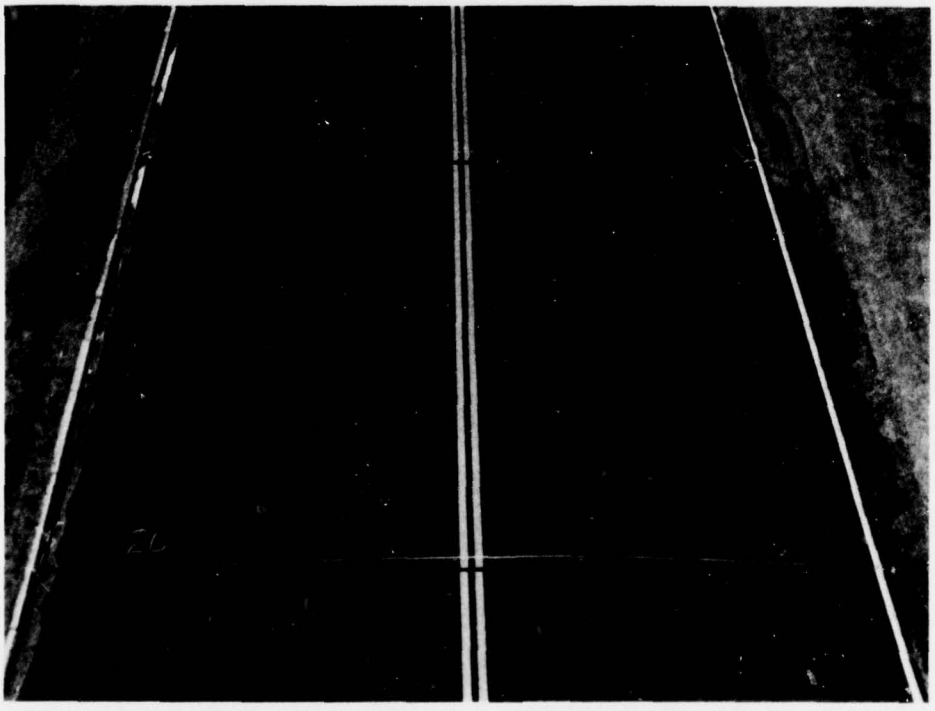
a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

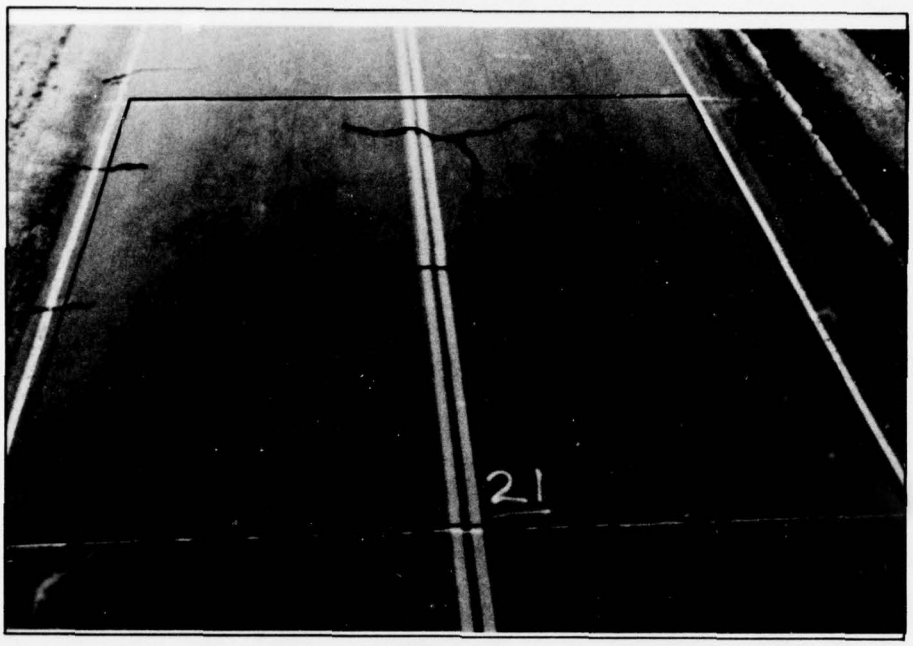
Photo 112. Fort Devens--U. S. Rubber section, Barnum Road

a. Condition of surface prior to overlay

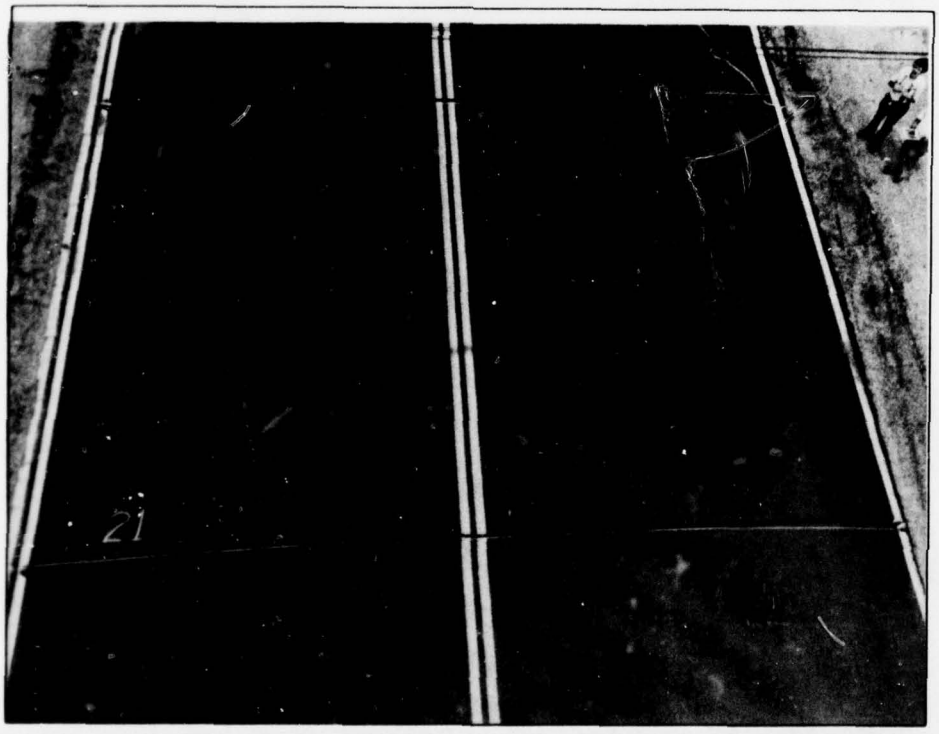


b. Condition of surface 6 months after overlay

Photo 113. Fort Devens--Mirafi 140 fabric section, Barnum Road

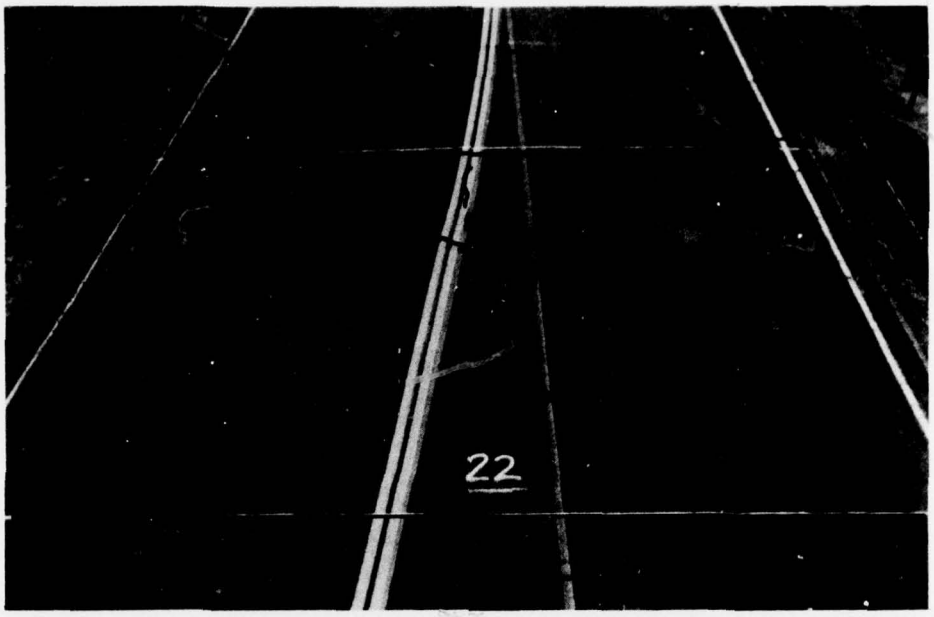


a. Condition of surface prior to overlay

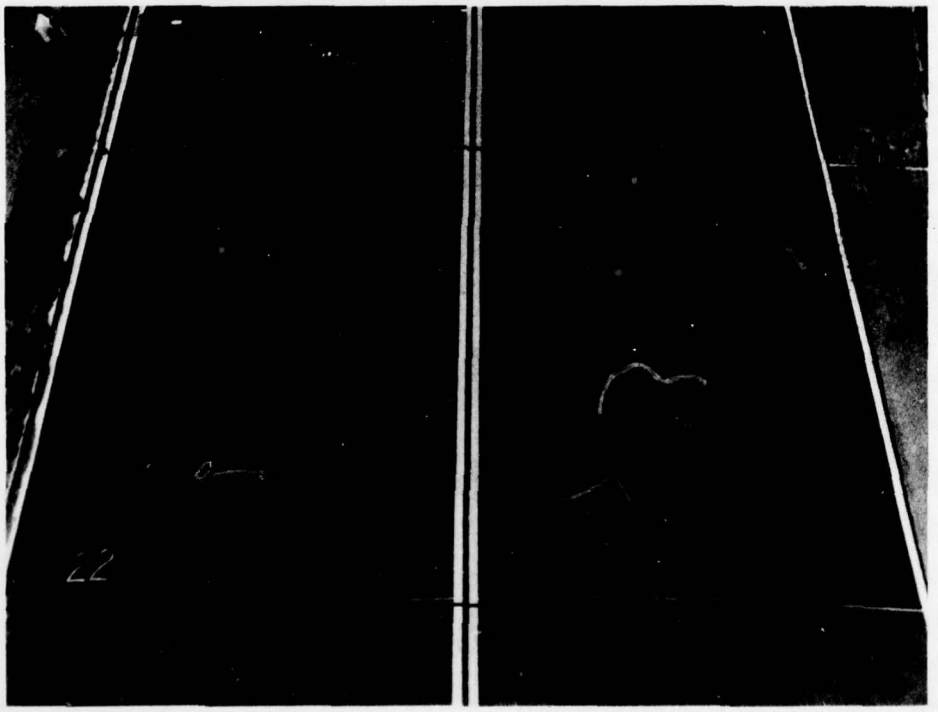


b. Condition of surface 6 months after overlay

Photo 114. Fort Devens--Bidim C-22 fabric section, Barnum Road



a. Condition of surface prior to overlay



b. Condition of surface 6 months after overlay

Photo 115. Fort Devens--control section, Barnum Road

Photo 116. Fort Devens--reflected crack
in Barnum Road outside of test areas

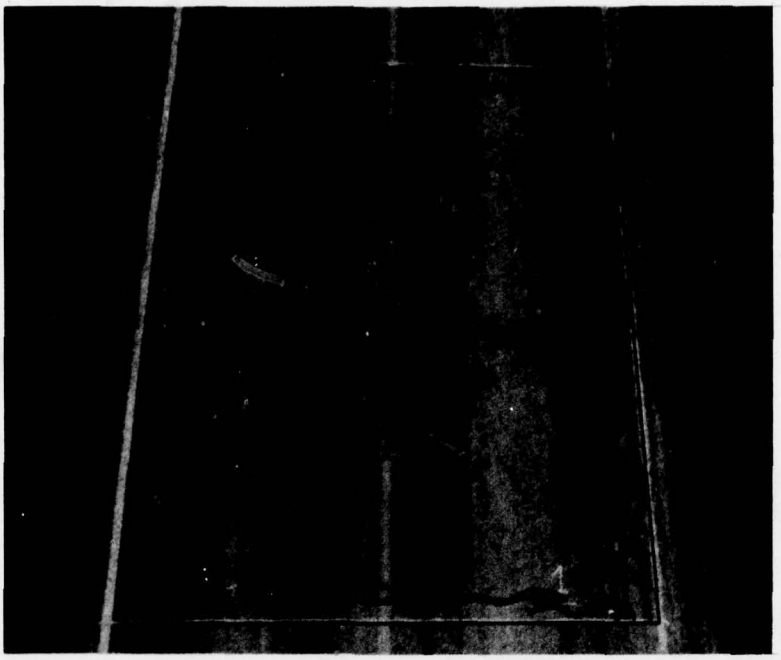


Photo 117. Fort Carson--condition of test area No. 1 prior to overlay

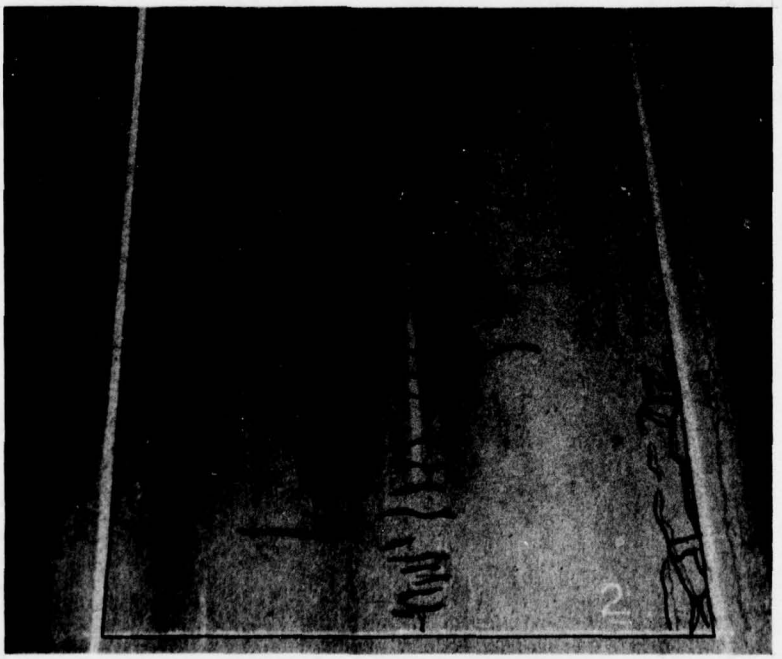


Photo 118. Fort Carson--condition of test area No. 2 prior to overlay

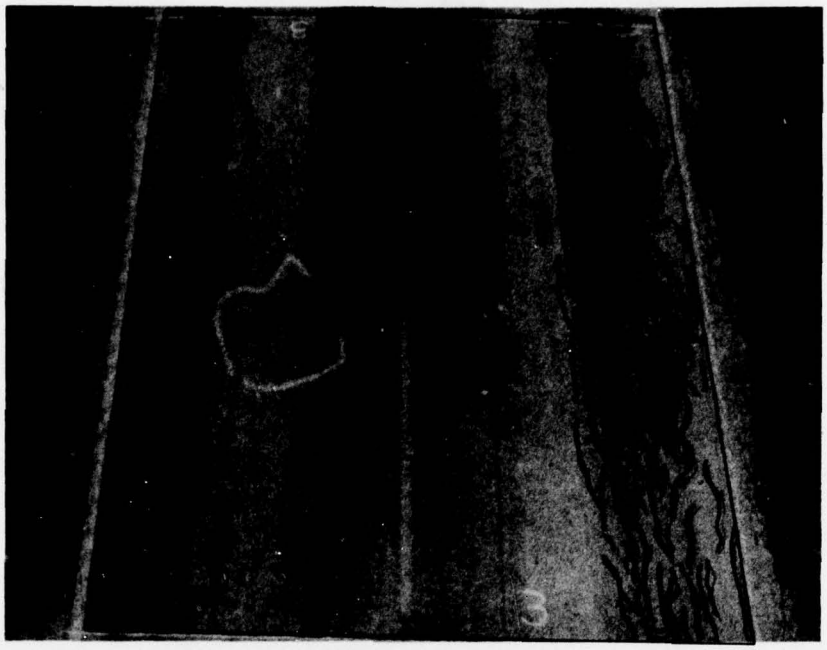


Photo 119. Fort Carson--condition of test area No. 3 prior to overlay

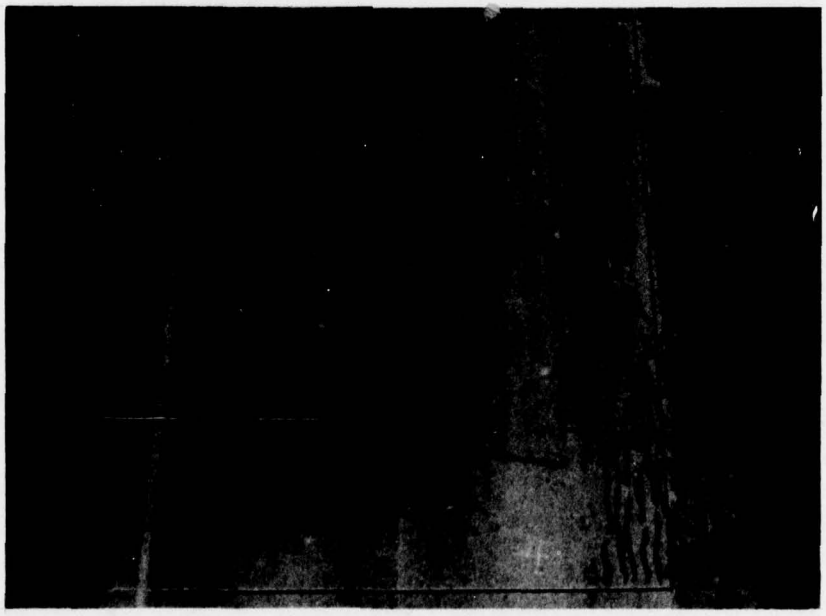


Photo 120. Fort Carson--condition of test area No. 4 prior to overlay

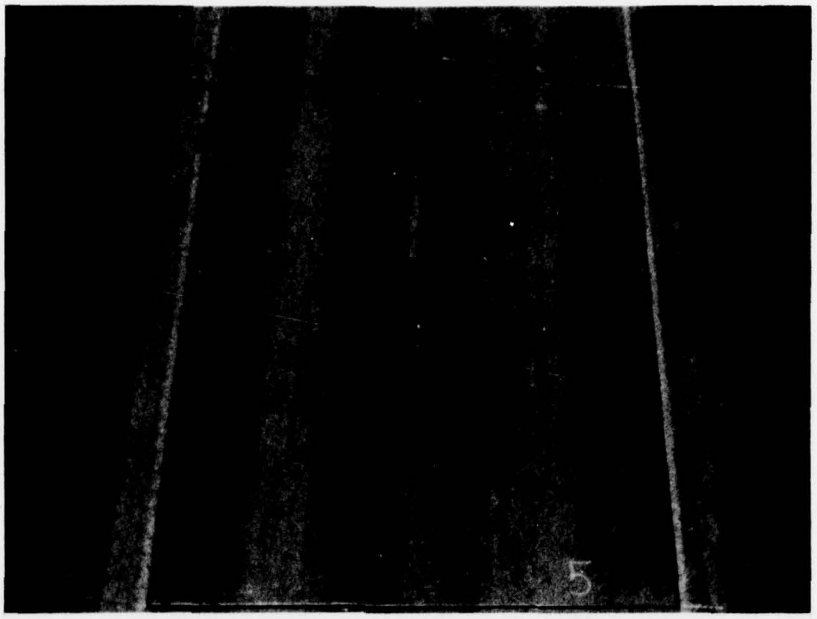


Photo 121. Fort Carson--condition of test area No. 5 prior to overlay

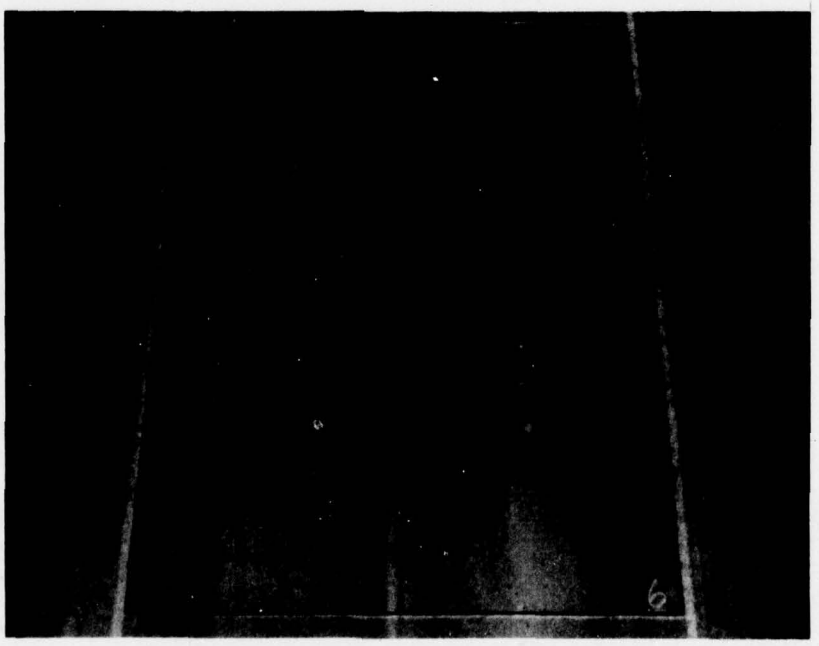


Photo 122. Fort Carson--condition of test area No. 6 prior to overlay

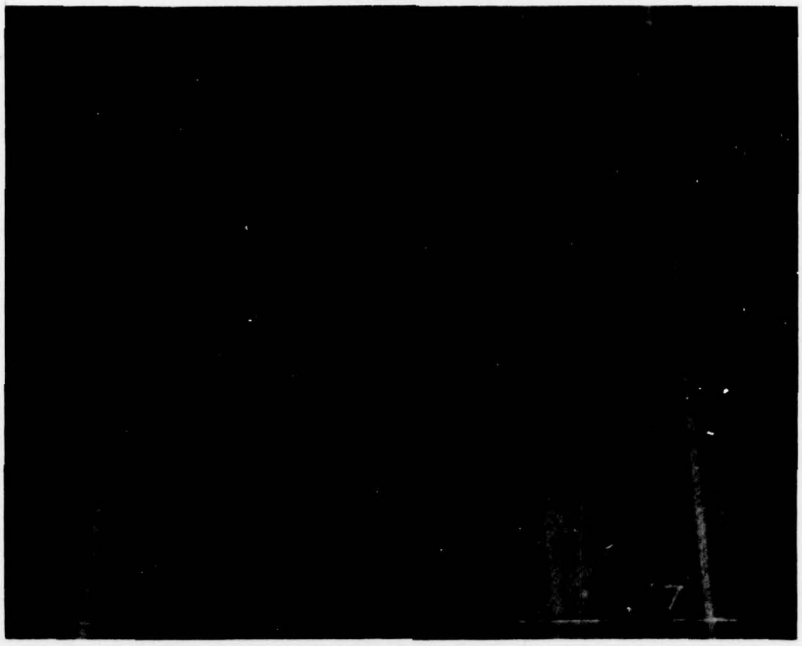


Photo 123. Fort Carson--condition of test area No. 7 prior to overlay

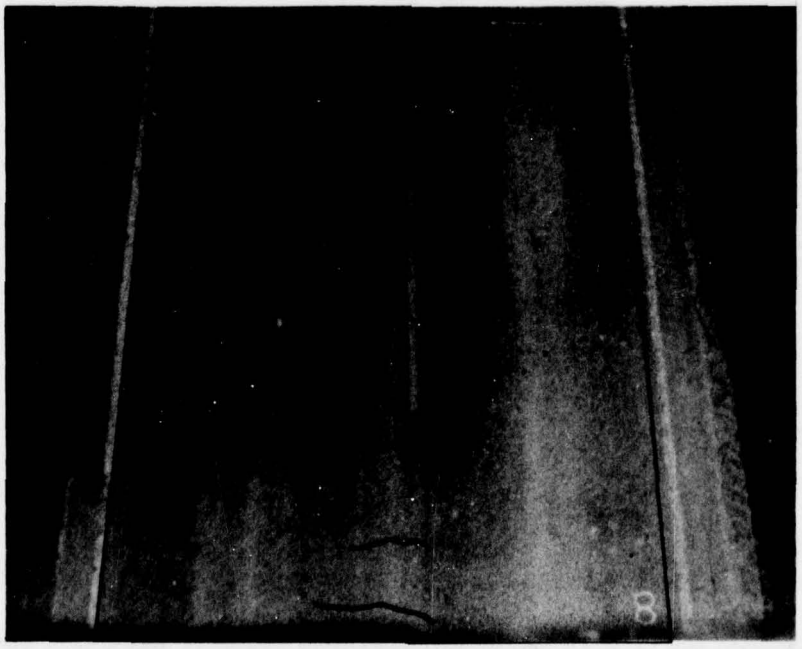


Photo 124. Fort Carson--condition of test area No. 8 prior to overlay

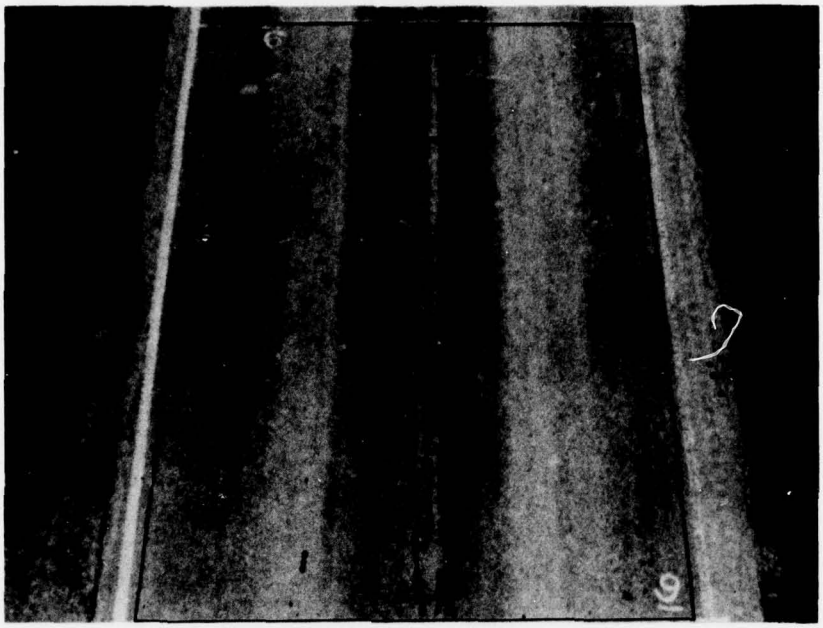


Photo 125. Fort Carson--condition of test area No. 9 prior to overlay

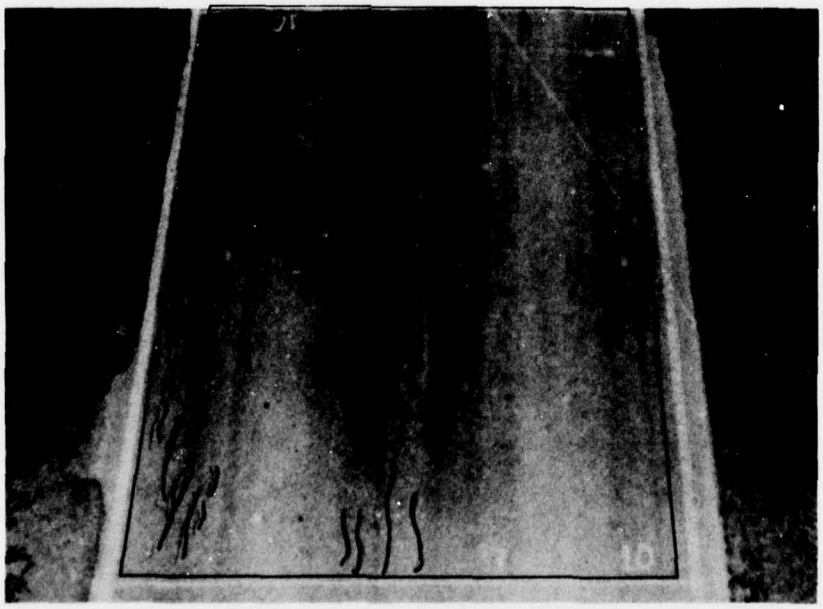


Photo 126. Fort Carson--condition of test area No. 10 prior to overlay

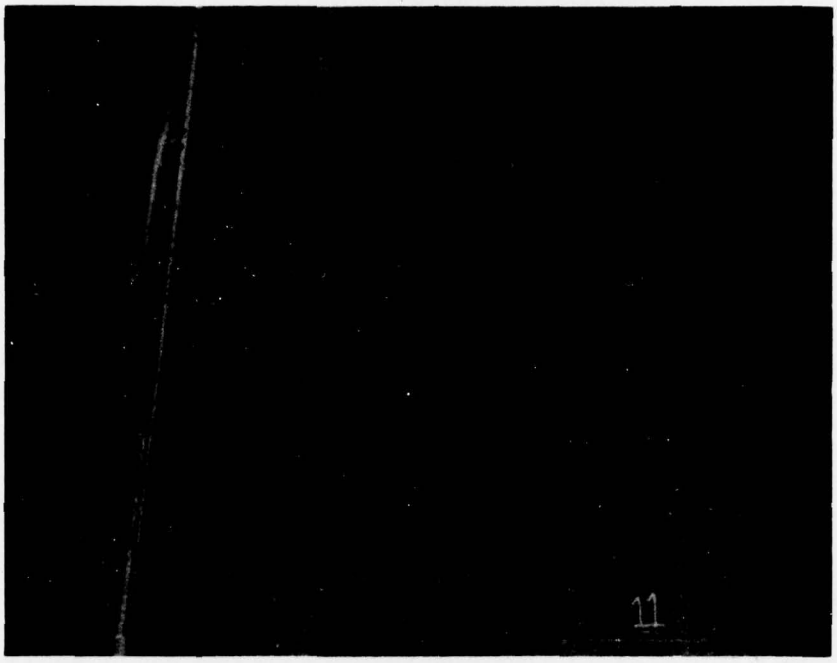


Photo 127. Fort Carson--condition of test area No. 11 prior to overlay

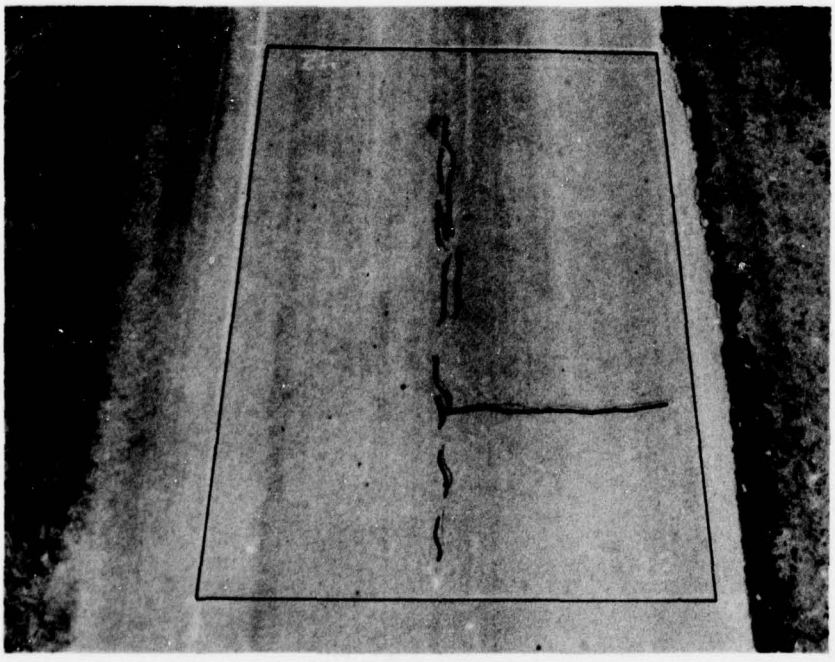


Photo 128. Fort Carson--condition of test area No. 12 prior to overlay

APPENDIX A: TECHNICAL SPECIFICATIONS FOR FABRIC REINFORCEMENT*

1.0 SCOPE: This specification covers the requirements for the placement of the polypropylene and polyester fabrics prior to the placement of the asphaltic concrete overlay.

2.0 APPLICABLE PUBLICATIONS:

2.1 Standard Specifications for Highways, Bridges, and Waterways:

2.2 American Association of State Highway and Transportation Officials (AASHTO):

M 20-70	Penetration Graded Asphalt Cement
M 208-72	Cationic Emulsified Asphalt

2.3 American Society for Testing and Materials (ASTM) Publications:

D 1250-73	Petroleum Measurement Tables

3.0 MATERIALS:

3.1 Fabrics: The polypropylene and polyester fabrics will be government furnished and available at the project site.

3.2 Liquid asphalt shall meet the requirement of AASHTO-M 20, grade AR-1000 or AC-10.

3.3 Emulsified asphalts shall meet the requirements of AASHTO-M 208, grade CRS-2.

4.0 CONSTRUCTION METHODS:

4.1 Preparation of Existing Pavement: Contractor shall clean the surface of dust, dirt, free water, and loose material.

4.2 Construction Procedures: The tack coat should be sprayed directly on the prepared pavement surface before application of the fabrics. The tack coat material shall be asphalt cement grade AR-1000 or AC-10 (preferably) or cationic emulsified grade CRS-2. The rate of application of the tack coat should be approximately 0.15 to 0.30 gal/sq yd or as recommended by the representative of the manufacturer of the fabric. Immediately after application of the tack coat, the fabric should be placed in or rolled out onto the tack coat. Every effort should be made

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* Appendix A is a copy of the technical specifications as appeared in the notification for bidders.

to lay the fabrics as smoothly as possible to avoid wrinkling. Manufacturer should provide technical support during laydown operations to insure proper installation of the fabric. After laydown, the fabrics should be brushed or squeegeed so as to remove air bubbles and insure intimate contact of the fabric with the road surface. The fabric should be bonded to the tack coat by rolling with a light pneumatic roller. Sufficient time should be allowed for setting of the tack coat prior to the spreading of the surface of the bituminous concrete material. Normally, sanding should not be required if the proper amount of tack coat has been applied; however, if the surface of the fabric should be too sticky for the subsequent overlaying operation, a light sprinkling of sand should be applied to the wet areas. At transverse overlaps (ending and starting of new roll of fabric), the fabric should be overlapped 12 in., and a spray of tack coat should be applied on the surface of the fabric to be overlapped. At longitudinal overlaps (along the length of the fabric), the fabric should be overlapped 9 in. with a tack coat applied to the surface of bottom fabric. The fabrics shall be cut to fit the section of pavement to be covered and to provide for the required overlaps as recommended by the manufacturer. The leading edge of the fabrics should be covered with a few shovelfuls of bituminous concrete surface course prior to the beginning of the spreading operation. Generally, the spreader can be supplied from trucks rolling over the in-place fabrics. Where possible, trucks should avoid direct contact with the tack material before rolling onto the fabric to avoid pullup of the fabric. If pullup does occur, light sprinkling of sand between fabric and wheels of trucks should be applied. After the overlay material has been placed, rolling operations can be carried out in the usual manner.

5.0 METHOD OF MEASUREMENT: The amount of bituminous material to be paid for will be the measured number of gallons of the material used in the accepted work, as determined by the Contracting Officer, corrected to gallons at 60°F in accordance with ASTM D 1250. A coefficient of volumetric expansion of 0.00025 per °F shall be used for asphalt emulsion. The number of square yards of tack coat placed will also be determined.

6.0 PAYMENT: The quantities of bituminous material and square yards placed, determined as specified in paragraph "Methods of Measurement," will be paid for at the respective contract unit prices in the bid schedule on which the contract is based, which payment shall constitute full compensation for all operations necessary to complete the work as specified herein.

APPENDIX B: TECHNICAL SPECIFICATIONS FOR ASPHALT-RUBBER MEMBRANE (INTERLAYER)*

1.0 SCOPE: This specification covers the requirements for the placement of an asphalt-rubber membrane (interlayer) which is placed on the existing pavement surface prior to the placement of the asphaltic concrete overlay.

2.0 APPLICABLE PUBLICATIONS:

2.1 Standard Specifications for Highways, Bridges, and Waterways:

2.2 American Association of State Highway and Transportation Officials (AASHTO):

AASHTO M 92	Wire Cloth Sieves for Testing Purposes
AASHTO T-85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T-202	Absolute Viscosity of Asphalts

2.3 American Society for Testing and Materials (ASTM) Publications:

D 75-71	Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials
D 140-70	Sampling Bituminous Materials

3.0 MATERIALS:

3.1 Rubber:

3.1.1 The rubber component for the U. S. Rubber test items shall be a blend of 40 percent powdered, reclaimed, "replasticized" rubber and 60 percent ground vulcanized rubber scrap, specially selected for its high natural rubber content. The total blend shall meet the following specifications (Sieve Analysis, AASHTO M 92):

Sieve Size	% Passing
No. 10	100
No. 30	60-80
No. 50	35-70
No. 100	10-25

* Appendix B is a copy of the technical specifications as appeared in the notification for bidders.

Natural rubber content shall be at least 30 percent by weight. Reclaimed "replasticized" rubber content shall be determined by a Mill Test as follows: When the weight of 40-50 grams of rubber retained on the 30-mesh sieve is added to the tight 6-in. rubber mill, the material will band on the mill roll in one pass and will usually be retained on the mill roll. This will indicate the presence of a suitable quantity of "replasticized" rubber.

3.1.2 The granulated crumb rubber (100 percent vulcanized) for the Sahuaro Petroleum test items shall meet the following requirements (Sieve shall comply with requirements of AASHTO M 92.):

Sieve Size	% Passing
No. 8	100
No. 10	98-100
No. 40	0-10

No specific standards for sampling and testing of granulated crumb rubber have yet been established. Until standards are established, it is recommended that the granulated crumb rubber be accepted if accompanied by a certificate of compliance from the supplier that the material has been tested during the grinding process and meets the gradation as specified.

3.1.3 The specific gravity of the material shall be 1.15 $\pm$ 0.2 and shall be free of fabric, wire, or other contaminating materials, except that up to 4 percent of calcium carbonate may be included to prevent the particles from sticking together.

3.2 Asphalt Cement to be Rubberized:

3.2.1 The asphalt cement to be used for the U. S. Rubber test items will generally be a grade AC-10 or AR-1000 and conform to the requirements of the following: The absolute viscosity of the original asphalt cement shall be between 600 and 1000 poises when tested in accordance with the requirements of AASHTO T-202.

3.2.2 The asphalt cement to be used for the Sahuaro Petroleum test items will generally be a grade AC-10 or AR-1000 and conform to the requirements of the following: The absolute viscosity of the original

asphalt shall not be greater than 1700 poises, and the penetration will not exceed 150.

3.3 Asphalt for Tack Coat:

3.3.1 No tack coat is required for the U. S. Rubber test items.

3.3.2 Tack coat for the Sahuaro Petroleum test items shall be a liquid asphalt of asphalt cement or emulsified asphalt (grade CRS-2).

3.4 Cover Material:

3.4.1 The cover material for use on the U. S. Rubber and Sahuaro test items will by the same and should comply with the following gradation:

Sieve Size	% Passing
3/8 in.	100
No. 4	30-60
No. 8	0-20
No. 200	0-2

4.0 FIELD SAMPLING AND TESTING:

4.1 Sampling: All samples of cover aggregates, unless otherwise specified, shall be in accordance with the requirements of ASTM D 75. All samples of bituminous material, unless otherwise specified, will be in accordance with the requirements of ASTM D 140. Contractor shall submit a minimum 150-lb sample of cover aggregate and two 1-gal samples of asphalt cement for approval to the engineer at least 10 days before commencing the construction.

4.2 Testing: Testing will be the responsibility of the Government. In the event of a material failing to meet the specifications and retesting is required, the cost of retesting will be charged to the Contractor. Materials shall be tested to establish compliance with the specified requirements.

5.0 MIXING ASPHALT AND RUBBER MATERIAL:

5.1 Rubberized Material for U. S. Rubber Test Items: The proportions of the two materials, by weight, shall be 80 percent, ± 2 percent, asphalt and 20 percent, ± 2 percent, rubber. The materials shall be intimately combined as rapidly as possible and mixed for a period of not less than 30 minutes at a temperature of between 350 and 400°F. The mixture may

be maintained at this temperature until applied to the roadway. The method and equipment for combining the rubber and asphalt shall be so designed and accessible that the engineer can readily determine the percentage, by weight, of each of the two materials being incorporated into the mixture.

5.2 Rubberized Material for Sahuaro Petroleum Test Items: The proportions of the asphalt and the granulated rubber, by weight, shall be 75 percent, ± 2 percent, asphalt and 25 percent, ± 2 percent, granulated rubber. All equipment utilized in the mixing and application of the asphalt-rubber material shall meet the requirements for equipment specified for the placement of asphalt materials as called for in the Standard Specifications. The method and equipment for combining the asphalt and rubber shall be so designed and accessible that the engineer can readily determine the percentage, by weight, of each of the two materials being incorporated into the mixture. The materials shall be combined as rapidly as possible for such time and at such a temperature that the consistency of the mix approaches that of a semi-fluid material. The temperature of the asphalt shall be between 350 and 450°F. After the full reaction described has occurred, the mix shall be cut back with kerosene. The amount of kerosene used shall not exceed 7-1/2 percent, by volume, of the hot asphalt-rubber composition as required for adjusting the viscosity for spraying or better "wetting" of the cover material. The kerosene shall have a boiling point of not less than 350°F, and the temperature of the hot asphalt rubber shall not exceed 350°F at the time of adding the kerosene.

6.0 CONSTRUCTION DETAILS:

6.1 Preparation of Surface: The existing pavement shall be cleaned of dust, dirt, free water, and loose material.

6.2 Application of Tack Coat: After cleaning and prior to the application of the asphalt-rubber membrane on the Sahuaro Petroleum test items, the existing pavement surface shall be treated with a tack coat of asphalt cement or emulsified asphalt, grade CRS-2. The asphalt cement shall be applied at the approximate rate of 0.05 gal/sq yd. If

the emulsified asphalt is utilized, it shall be applied at the approximate rate of 0.07 gal/sq yd. As hereinbefore specified under paragraph 3.3.1, no tack coat will be applied on the U. S. Rubber test items.

6.3 Application of Asphalt-Rubber Membrane: Placement of the asphalt-rubber membrane shall be made only under the following conditions:

(1) The ambient air temperature is above 50°F.

(2) The pavement is absolutely dry.

(3) The wind conditions are such that a satisfactory membrane can be achieved.

6.3.1 For U. S. Rubber Test Items: The hot asphalt-rubber mixture shall be applied at a minimum rate of 0.70 gal/sq yd. The distributor shall be capable of spreading the asphalt rubber in accordance with the tolerances outlined in the Standard Specifications, except that the maximum allowable deviation shall be 0.06 gal/sq yd. All transverse joints shall be made by placing building paper over the end of the previous application, and the joining application shall start on the building paper. Once the application process has progressed beyond the paper, the paper shall be disposed of as directed by the engineer. All longitudinal joints shall be lapped approximately 4 in.

6.3.2 For Sahuaro Petroleum Test Items: The hot asphalt-rubber mixture shall be applied at a minimum rate of 0.60 gal/sq yd (based on 7-1/2 lb per hot gallon). The distributor shall be equipped with an internal mixing device capable of maintaining a completely homogeneous blend of the ingredients. The distributor shall be capable of spreading the asphalt-rubber mixture in accordance with the tolerances outlined in the Standard Specifications, except that the maximum deviation from the specified rate shall not exceed 0.06 gal/sq yd. After reaching the proper consistency, application of the material shall proceed immediately and in no case shall the material be placed when a uniform application is not being achieved. All transverse joints shall be made by placing building paper over the end of the previous application, and the joining application shall start on the building paper. Once the application process has progressed beyond the paper, the paper shall be disposed of

as directed by the engineer. All longitudinal joints shall be lapped a minimum of 2 in.

6.4 Application of Cover Material: Immediately after the asphalt-rubber membrane has been placed, cover material should be applied. For estimating purposes only, the rate of application should be 30 lb/sq yd (dry weight). A sample of the cover material shall be submitted for approval as hereinbefore stated in paragraph 4.1 at least 10 days before it is to be used, and the engineer will then determine the exact rate of application. The cover material should be at least as dry as material dried in accordance with the requirements of Section 4.2 of AASHTO T-85 at the time of application.

6.5 Rolling: At least three self-propelled pneumatic rollers conforming to the requirements of the Standard Specifications be provided to accomplish the required rolling, except that the rollers shall carry a minimum of 5000 lb on each wheel and a minimum air pressure of 100 lb/sq in. in each tire. At some locations or where production rates require, fewer rollers may be utilized as directed by the engineer. Sufficient rollers shall be furnished to cover the width of the spread with one pass. It is imperative that the first pass be made immediately behind the spreader, and if the spreading is stopped for any reason, the spreader shall be moved ahead so that all cover material spread may be immediately rolled. The rolling shall continue until four complete coverages have been made. Final rolling shall be completed within 2 hr after the application of the cover material.

6.6 Traffic Control: Except for times when it is necessary that hauling equipment and/or pilot trucks must travel on the newly applied membrane, traffic of all types shall be kept off the membrane until it has had time to set properly. The speed of all hauling equipment and pilot trucks shall not exceed 15 mph. The minimum traffic free period shall not be less than 3 hr.

6.7 Removing Loose Cover Material: The power broom used in removing loose cover material shall be a rotary sweeper type. Sweeping shall be performed at daybreak of the day following placement, or at any time it is required to remove loose cover material that is detrimental to the

membrane or is an inconvenience to traffic. Additional sweeping may be required just prior to the placement of the asphaltic concrete. If because of temperatures or other causes, there is a displacement of the embedded cover material, sweeping shall be discontinued until such time as there will be a retention of cover material. Additional final sweeping shall be done, and all excess cover material removed prior to the placement of the asphaltic-concrete overlay.

6.8 Placement of Asphalt-Concrete Overlay: The placement of the first lift of the asphaltic-concrete overlay shall be completed within 24 hr after application of the asphalt-rubber membrane, except that at the Contractor's option, this period may be extended to a maximum of 7 calendar days, provided the Contractor accepts responsibility for maintaining the integrity of the membrane during the additional time. Any blotting, flushing with water, patching with asphalt rubber, additional sweeping, or other means necessary and approved by the engineer, after the first 24 hr, will be at the Contractor's expense.

6.9 Sources of Rubber Material: The only known sources of rubber for these applications are:

Sahuaro Petroleum and Asphalt Co.
P. O. Box 6536
Phoenix, Arizona 85005

U. S. Rubber Reclaiming Co.
1205 Monroe Street
Vicksburg, Mississippi 39180

7.0 METHOD OF MEASUREMENT AND BASIS OF PAYMENT: The asphalt rubber will be measured and paid for per ton of the mixture under item Asphalt Cement (for membrane seal)(Grade AC-10 or AR-1000)(rubberized) in accordance with the Standard Specifications and including asphalt, granulated rubber, and kerosene based on 7-1/2 lb per hot gallon. The cover material will be measured and paid at the contract unit price per ton which price shall be full compensation for the item complete, including rolling and brooming as hereinbefore described and specified.

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